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Department of Economics

Intrahousehold Insurance and its Implications for Macroeconomic Outcomes

Nawid Siassi

Thesis submitted for assessment with a view to obtaining the degree of Doctor of Economics of the European University Institute

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Abstract

Most theoretical and empirical work on consumption, labor supply and saving decisions has been based on the paradigm that households behave as single agents. While this approach is often convenient, it relies on very restrictive assumptions. In recent years, there has been significant progress in developing a more satisfactory theory of decision making *within* households. The main contribution of this thesis is to explore the significance of intrahousehold risk sharing in the presence of uninsurable, idiosyncratic risk. If individuals are unable to rely on complete asset markets, the extent to which they can cope with uncertainty crucially hinges on the set of risk sharing channels. Despite its vast empirical significance, insurance from the family as one of these channels has mostly been overlooked in the literature.

The first chapter investigates the significance of family insurance for savings and labor supply. An economy in which individuals can share risk within households generates aggregate precautionary savings that are substantialy smaller than in a similar economy that lacks access to insurance from the family. Intrahousehold risk sharing has its largest impact among wealth-poor households. While the wealth-rich use mainly savings to smooth consumption across unemployment spells, wealth-poor households rely on spousal labor supply. The second chapter documents some stylized facts for the distributions of earnings and wealth across single and married households and presents a theoretical framework that can successfully account for the data. Assortative matching, the effective tax bonus for married couple and directed bequests are found to be key determinants for higher per-capita earnings and net worth among married individuals. The third chapter explores how intrahousehold insurance interacts with the design of unemployment benefit programs. My findings indicate that fiscal policy can take very distinct effects depending on whether intra-household risk sharing is available or not. I also find potential efficiency gains from gender-based taxation.

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Introduction

Over the last decades, most theoretical and empirical work on consumption, labor supply and saving decisions has been based on the paradigm that households behave as single agents. While this approach is often convenient and has led to many valuable insights, it relies on very restrictive assumptions. In recent years, there has been significant progress in developing a more satisfactory theory of decision making *within* households. Describing the allocation process within the family such that it captures aspects of cooperation, conflicts and insurance is not only crucial for understanding consumption, labor supply and saving decisions. At the same time, it has important implications for policy design. A careful evaluation of the theory and its consistency with key empirical facts is therefore indispensable.

The thesis at hand contributes to this strand of research by exploring the significance of intrahousehold risk sharing in the presence of uninsurable, idiosyncratic risk. There is ample evidence that the benchmark assumption of asset market completeness does not merit empirical justification. This observation has led to the development of a new generation of dynamic general equilibrium models featuring incomplete asset markets and household heterogeneity. At the heart of these models lies the central question of how well individuals can cope with uncertainty if they cannot fully rely on private insurance markets. The answer to this question crucially hinges on the set of risk sharing channels individuals have at their disposal. Despite its vast empirical significance, insurance from the family as one of these channels has mostly been overlooked in the literature. The unifying theme of this work is to shed more light on the way risk sharing within households shapes individual and aggregate outcomes.

The first chapter, a joint project with Salvador Ortigueira, investigates the significance of family insurance for savings and labor supply. We present a model where workers (females and males) are subject to idiosyncratic employment risk and where capital markets are incomplete. A household is formed by a female and a male, who make collective decisions on consumption, savings and labor supplies. In a calibrated version of our model, we find that precautionary savings are only 55% of those generated by a similar economy that lacks access to insurance from the family. We also find that intrahousehold risk sharing has its largest impact among wealth-poor households. While the wealth-rich use mainly savings to smooth consumption across unemployment spells, wealth-poor households rely on spousal labor supply. For instance, in the group of households with wealth less than two months worth of income, average hours worked by wives of unemployed husbands are 8% higher than those

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worked by wives of employed husbands. This response in wives' hours makes up 9% of lost family income. We also find crowding out effects of public unemployment insurance that are comparable to those estimated from the data.

The second chapter shifts the focus to the foundations of cross-sectional inequality. Most existing theories of inequality ignore the role of the family, even though marriage appears to be one of the most important determinants of economic prosperity. I document that the disaggregated distributions of earnings, income and wealth across single households differ substantially from those of married households. Most strikingly, married people have on average 50 percent higher labor earnings, and they hold 34 percent more net worth. To account for these empirical facts, I develop a theory based on an otherwise standard incomplete-markets OLG model with ex-ante identical agents, who (i) are randomly selected into single or married households at the beginning of their economic life; (ii) face uninsurable labor market risk henceforth; (iii) and make collective decisions if married. In a calibrated version of the model, I show that positive assortative matching, the effective tax bonus for married couple and directed bequests are the key determinants for married households' higher average earnings and wealth. I also assess the implications of a policy reform that abolishes the possibility to file taxes jointly for married couples. My findings indicate considerable welfare gains associated with this reform.

The third chapter explores how intrahousehold insurance interacts with the design of unemployment benefit programs. Private risk-sharing agreements within the household, e.g. in families with multiple income earners, can crucially affect the trade-off between public risk sharing and distortionary taxation. In an economy with female and male workers who face uninsurable employment risk, I evaluate the implications of various reforms to the unemployment insurance schedule. In order to assess the role of family insurance, I study two polar cases: one economy in which family insurance is available, and one in which it is not. I find that fiscal policy can take very distinct effects across the two economies. For instance, a more generous benefit program favors males and implies welfare losses for females if family insurance is available; if not, the opposite is true. Lending support to a recent debate, my findings also indicate efficiency gains from gender-based taxation.

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Chapter 1

How important is Intrahousehold Risk Sharing for Savings and Labor Supply?

(with Salvador Ortigueira)

Keywords: Intrahousehold risk sharing; Collective household model; Idiosyncratic unemployment risk; Incomplete markets; Precautionary motive.

JEL Classification Numbers: D13, D91, E21.

1.1 Introduction

The lack of a formal, private insurance market against employment risk makes this type of risk different from most of others faced by individuals. Even though public, compulsory unemployment insurance schemes are present in many countries, they typically fall short of providing full insurance and workers must rely on self-insurance and on informal insurance mechanisms in order to smooth consumption across unemployment spells. Precautionary savings and labor supply are the two instruments individuals can use as self-insurance against employment risk. The family, on the other hand, is the main informal insurance mechanism available to individuals, with the standard argument being that information and payment enforceability are better within than between households.[1]

In this paper, we present an incomplete markets economy with idiosyncratic employment risk

[1] Blundell, Pistaferri and Preston (2008) estimate the degree of consumption insurance from U.S. data and find evidence that the family plays an important insurance role.

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and assess quantitatively the role of the family as provider of insurance. Intrahousehold risk sharing, more than any other informal insurance mechanism, has important behavioral implications that affect not only the demand of self insurance, but also how this is crowded out by public insurance programs. Indeed, recent empirical evidence on patterns of insurance against employment risk found in a large panel of U.S. households sheds light on these crowding out effects. More specifically, Cullen and Gruber (2000) and Engen and Gruber (2001) estimate the response in two forms of insurance —accumulation of financial assets and spousal labor supply— to changes in the generosity of unemployment benefits and find significant crowding out effects on both. The extent to which public insurance crowds out other forms of (private) insurance is of paramount importance for public policy assessment [see, e.g., Attanasio and Rios-Rull (2000), Di Tella and MacCulloch (2002), Golosov and Tsyvinski (2007) and Chetty and Saez (2010) for analyses on the optimal level of social insurance when other forms of private insurance are also available.]

The model economy we present in this paper consists of a large number of two-person households, each pooling risks and making *collective* decisions on individual consumptions, labor supplies and joint savings in a risk-free asset, subject to a borrowing constraint. The two persons forming a household, a female and a male, are assumed to have different individual preferences for risk and different elasticities of labor supply. Individual weights in the household's utility function are determined, among other variables, by their relative earning ability. There is a firms sector producing an homogeneous good with capital and labor services, and a government providing public unemployment insurance. In order to assess the consequences of within-household risk sharing, the equilibrium in this economy is then compared to that arising in an economy where individuals lack access to insurance from the family and are left with self-insurance and public benefits as their only instruments to cope with employment risk. This latter framework corresponds to a standard Aiyagari-Huggett economy augmented with a labor-leisure choice, which has been studied by, e.g., Flodén and Lindé (2001), Marcet, Obiols-Homs and Weil (2007) and Pijoan-Mas (2006), among others.

Since the equilibrium of our model economy contains a distribution of households over financial assets and spouses' employment status, we can assess not only the average effects of intrahousehold risk sharing but also its effects for different groups of households. Thus, in a calibrated version of our model we find that precautionary savings are only 55% of those generated by a similar economy that lacks access to insurance from the family. This is a large drop in precautionary savings that should be taken into account when assessing the ability of general equilibrium models with idiosyncratic income risk to generate large volumes of precautionary savings (see, e.g., Díaz, Pijoan-Mas and Ríos-Rull 2003 for a discussion on the

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extent of precautionary savings in these models).

We also find that intrahousehold risk sharing has its largest impact among wealth-poor households. While the wealth rich use savings to smooth consumption across unemployment spells, wealth-poor households rely on spousal labor supply. For instance, in the group of households with wealth less than two months worth of income, average hours worked by wives of unemployed husbands are 8% higher than those worked by wives of employed husbands. Moreover, this response in wives' hours makes up 9% of lost family income.

The crowding out effects of public unemployment insurance in our calibrated economy are comparable to those found in the data. On the contrary, the standard Aiyagari-Huggett model of self insurance over-predicts the response in savings to changes in public insurance by a large margin. For example, this model predicts an elasticity of asset holdings with respect to unemployment benefits that is almost four times the elasticity estimated by Engen and Gruber (2001). As should be apparent, the Aiyagari-Huggett model cannot account either for the crowding out effects of unemployment benefits on spousal labor supply. Hence, models that abstract from risk sharing at the level of the household introduce an important bias both in the extent of the precautionary motive in the face of unemployment risk and in the distortionary effects of public insurance programs on savings and labor supply.

There is a vast literature, both empirical and theoretical, assessing the effects of idiosyncratic income risk on consumption, labor supply and savings. With only few exceptions, this literature adopts the bachelor household formulation in order to measure individual responses to income shocks and the degree of endogenous self-insurance. A recent example of this type of exercise is the paper by Low, Meghir and Pistaferri (2008). These authors assume that individuals (they focus only on males) are subject to a rich array of idiosyncratic shocks, including productivity and employment shocks. These shocks are assumed to differ in their available insurance opportunities (employment shocks are partially insured by the public unemployment insurance system while productivity shocks are not). The authors then use a bachelor household model to measure the effects of these shocks and the individual willingness to pay to avoid them. Since they consider endogenous mobility choices, their paper extends previous results in the literature by adding a new channel from shocks to individual responses to shocks.

Kotlikoff and Spivak (1981) is one of the first papers in economics to study the family as a provider of insurance to its members. In particular, they present a model where the only risk is that of unexpected longevity. Their model abstracts from labor earnings and assumes that an initial level of wealth is the only source of resources available to consumers. They show that

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efficient risk-sharing within the family closes much of the utility gap between no annuities and complete annuities. For example, the utility gain of marriage at age 30 is about 50% of the utility gain of an annuities market. In a model with these ingredients, Kotlikoff, Shoven and Spivak (1986) study precautionary savings arising from longevity risk. They compare savings under perfect insurance markets with savings under intrahousehold risk sharing. They find significant differences in savings.

A more recent exception to the use of the bachelor household formulation is the work of Attanasio, Low and Sánchez-Marcos (2005), who present a partial equilibrium model with a two-person *unitary* household to assess the response of female labor market participation (extensive margin) to idiosyncratic earnings risk within the family. In their model, male participation is exogenous. An important feature of this model is the process of female human capital formation, which is assumed to depend on labor market participation. The authors find that the higher the uncertainty the higher female participation. They also find that the welfare cost of uncertainty is lower when households can adjust female labor market participation.

Heathcote, Storesletten and Violante (2010) also use a two-person, unitary household model to study the welfare implications of the observed changes in the U.S. wage structure. In particular, they present an incomplete-markets, life-cycle model to quantify the effects of the rising college premium, the narrowing wage gender gap and the increasing wage volatility. Their model allows for an endogenous education choice and for a process matching females and males into households. Even though the welfare consequences of the above-mentioned changes in wages are highly heterogenous across different types of households, they find that, on average, recent cohorts of households enjoy welfare gains, as the new structure of wages translates into higher educational attainment.

Unitary models of the household, however, assume a utility function for the household and are thus silent about the decision process between its members. The collective model (see Browning, Chiappori and Lechene 2006 for a formal definition of this model) establishes instead that this decision process leads to within-household Pareto optimality and that Pareto weights on individuals' private utility functions depend on prices, policy variables and distribution factors. Thus, in this latter model, changes in the wage gender gap, in public unemployment benefits and/or in tax rates imply within-household distributional effects that unitary models fail to capture. Moreover, in economies with idiosyncratic risks and incomplete asset markets, these effects, along with heterogeneity in individuals' risk preferences, have sizable implications for precautionary savings and labor supplies. Consequently, the two

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models of the household predict different crowding out effects of public unemployment insurance. Tests of these two competing models of the household have been carried out by, e.g., Fortin and Lacroix (1997) and Browning and Chiappori (1998), who find evidence against the unitary model. In particular, they reject the income pooling restrictions and the symmetry of cross-wage effects which are embodied in this model.

The remaining of the paper is organized as follows. Section 2 describes the economic environment and presents the problems solved by the bachelor and the collective household. Section 3 defines a stationary equilibrium with incomplete markets in the collective household economy. It also presents the parameterization and calibration of this economy; it shows the steady-state equilibrium and discusses some features of the policy functions. Section 4 presents the main results on the aggregate and individual consequences of intrahousehold risk sharing. Section 5 concludes. The paper contains four appendices.

1.2 The Economic Environment

Consumers The economy is populated by a continuum of measure two of infinitely-lived workers/consumers. Half of this population of workers/consumers will be referred to as females, and the other half as males. All enjoy the consumption of an aggregate good and of leisure time (with possibly different utility functions). Agents supply time to work in the production sector and face idiosyncratic labor market risk in the form of employment shocks.

Employment shocks, s, take on values in $S \equiv \{0, 1\}$ and follow a Markov chain with transition matrix Π^i, where superscript i denotes the gender: females (f) and males (m). Thus, $\pi^i_{s'|s}$ is the probability for an agent of gender i to receive employment shock s' tomorrow conditional on employment shock s today, for $i = f, m$. These probabilities satisfy $\sum_{s'} \pi^i_{s'|s} = 1$, $\pi^i_{s'|s} > 0$, and $\pi^i_{1|1} \geq \pi^i_{1|0}$ for $i = f, m$. The long-run probabilities of the two employment shocks in S are denoted by q^i_0 and q^i_1. There are no others shocks in the economy.

Markets are incomplete. The only asset in the economy is a non-state contingent asset that pays the risk-free interest rate r. Moreover, there is a minimum level of asset holdings, $\underline{a}$, which is a borrowing or liquidity constraint.

Lifetime preferences for an agent of gender i over stochastic consumption and leisure streams are given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U^i(c_t, l_t), \quad \text{for} \quad i = f, m, \tag{1.2.1}$$

where c_t denotes consumption and l_t is leisure. We make the following assumptions on U^i:

A1. Utility $U^i(c,l) : R_+ \times [0,1] \to R$ is bounded, continuous and twice continuously differentiable in the interior of its domain.

A2. Utility is separable in consumption and leisure.

A3. Utility U^i is strictly increasing and strictly concave in each of its arguments. Moreover,
$\lim_{c\to 0} U_c^i(c,l) = +\infty$, and $\lim_{l\to 0} U_l^i(c,l) = +\infty$.

Firms Production of the aggregate good is conducted by competitive firms. Production technology is represented by the neoclassical production function $F(K,L)$, where K is the aggregate stock of capital and L is aggregate labor. The depreciation rate of capital is denoted by $\delta > 0$. Throughout the paper, we will assume the standard Cobb-Douglas production function, $F(K,L) = K^\alpha L^{1-\alpha}$, where $0 < \alpha < 1$ is the capital's share of income and $L \equiv \lambda L^m + (1-\lambda)L^f$. That is, female and male labor are perfect substitutes and parameter $0 < \lambda < 1$ pins down relative, gross-of-taxes wages. The firm's maximization problem is static: given a rental price of capital r and gross wages for females and males $\bar{w}^f$ and $\bar{w}^m$, respectively, first-order conditions are:

$$
\begin{aligned}
F_K(K,L) &= r+\delta &\quad (1.2.2)\\
\lambda F_L(K,L) &= \bar{w}^m &\quad (1.2.3)\\
(1-\lambda)F_L(K,L) &= \bar{w}^f. &\quad (1.2.4)
\end{aligned}
$$

Government There is a government that provides public insurance against unemployment shocks. The government pays out benefits b^i to unemployed workers of gender $i = f, m$. Only workers who receive an unemployment shock are entitled to benefit payments. The government finances its expenditures by levying linear taxes on labor income: given tax rates τ^i, we will denote after-tax wage rates by $w^i = (1-\tau^i)\bar{w}^i$. The government is required to balance its budget on a period-by-period basis.

1.2.1 The Bachelor versus the Collective Household Model

We now consider two different risk-sharing arrangements and study their implications for labor supply (of both females and males) and for precautionary savings. Each arrangement defines in turn a different type of household. We start out by presenting the problem of the bachelor household. This is the definition of the household that has dominated not only the literature on precautionary savings, but also most of the macroeconomic literature. The defining feature of this type of household is that a single breadwinner chooses sequences of

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consumption, leisure and asset holdings in order to maximize his/her own lifetime utility. In most studies adopting this framework, the income process is estimated using data on males. The second type of household we study is a dynamic version of the collective household model pioneered by Chiappori (1988). In this latter case, we assume that two adult individuals, with possibly different preferences, wages and unemployment risk, form a household and then make collective decisions on consumptions, labor supplies and savings. In order to understand the consequences of intrahousehold risk sharing we compare allocations generated by this latter model with those emerging under the bachelor formulation.

Bachelor Households

A household formed by a single agent of gender i solves

$$v^i(s,a;w^i,r) = \max_{c,l,a'} \left\{ U^i(c,l) + \beta \sum_{s'} \pi^i_{s'|s} v^i(s',a';w^i,r) \right\} \tag{1.2.5}$$

$$\text{s.t.} \quad c + a' = w^i(1-l)s + (1-s)b^i + (1+r)a \tag{1.2.6}$$

$$c \geq 0,\ 0 \leq l \leq 1, \ \text{ and } \ a' \in [\underline{a}^i, \bar{a}], \tag{1.2.7}$$

where $\pi^i_{s'|s}$ are the elements of Π^i. The minimum level of assets this agent can hold is denoted by $\underline{a}^i$. A version of this model where there is a measure one of same-gender workers is the workhorse model in the literature of uninsurable idiosyncratic risk, precautionary savings and labor supply (see, e.g., Marcet, Obiols-Homs and Weil 2007). Flodén and Lindé (2001) and Pijon-Mas (2006) also study a model with a measure one of same-gender, bachelor households where workers receive idiosyncratic shocks to the efficiency units of labor supply, instead of an employment/unemployment shock.

By construction, the bachelor household does not engage in informal insurance arrangements with other workers. The only sources of insurance available to this type of household are the public unemployment insurance system, own savings and own labor supply.

Collective Households

We now consider two-person, collective households formed by an egotistical female and an egotistical male. We assume that the two members of the household share labor market risk in such a way that intrahousehold allocations are efficient.[2] Following the literature of collective households (see Chiappori and Donni 2010 for a recent survey), the utility of each

[2] It should be noted, however, that in two-person households the number of family members involved in risk pooling is too small to achieve full insurance against labor market risk.

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individual in the household carries a weight, reflecting the relative power of that individual in the household. Individual weights are assumed to depend on variables such as premarital wealth, the population sex ratio, relative earnings and government policy. Under full commitment, that is, when household members can commit to future intrahousehold allocations, individual weights are set when the household is formed and remain unchanged thereafter. Thus, transitory shocks, which are small relative to lifetime income, have no effect on individual weights. Only variables known or predicted at the time of household formation can affect those weights.[3] In our model there are four sources of earning differences between females and males that affect relative Pareto weights: 1) They have different gross wages; 2) They may pay different tax rates; 3) They may receive different levels of unemployment benefits; and, 4) Finally, females and males may be subject to different employment and unemployment spells. We write the Pareto weight on female's utility as $\mu(x, \boldsymbol{z}) \in (0,1)$, where function μ is assumed to be differentiable with respect to its first argument. Variable x is a measure of the relative earning ability of the two spouses, which we write as,

$$x \equiv \frac{q_1^f(1-\tau^f)\bar{w}^f + q_0^f b^f}{q_1^m(1-\tau^m)\bar{w}^m + q_0^m b^m}, \tag{1.2.8}$$

where q_i^j for $j = f, m$ and $i = 0, 1$ is, as written above, the long-run probability of employment state i for an agent of gender j. Vector $\boldsymbol{z}$ includes variables such as the population sex ratio, the initial contribution to household wealth, etc., which we do not model explicitly in this paper. It must be noted that in our model the Pareto weight function, $\mu(x, \boldsymbol{z})$, is not obtained as the outcome of an explicit bargaining process between females and males. Instead, we will use estimates of the sharing rule provided by Browning, Bourguignon, Chiappori and Lechene (1994) to parameterize and solve our model.[4]

Household-level state variables for the two-person, collective household are the vector of employment shocks $\boldsymbol{s} = (s^f, s^m)$, which we assume to be uncorrelated within the household,[5] and the level of asset holdings, a. The state space of a household is $X = S \times S \times [\underline{a}, \bar{a}]$. We denote by $\mathcal{B}$ the Borel sigma algebra of X. The transition matrix for $\boldsymbol{s}$ is denoted by Π and obtained from the individual transition matrices as $\Pi = \Pi^m \otimes \Pi^f$. The vector of after-tax wages for the household, (w^f, w^m), is denoted by $\boldsymbol{w}$.

[3]For a test of intrahousehold commitment to future allocations, see Mazzocco (2007). Using data from the Consumer Expenditure Survey, this author rejects the hypothesis of commitment. Since our model abstracts from permanent shocks and assumes only transitory shocks to labor income, we will retain, for the sake of analytical tractability, the assumption of commitment.

[4]In a recent paper Heathcote, Storesletten and Violante (2009) endogenize the Pareto weight as the solution to a symmetric Nash bargaining problem within the household.

[5]We will discuss further this independence assumption below.

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The maximization problem of a collective household with Pareto weight $\mu(x, \boldsymbol{z})$ on female's utility is

$$V(\boldsymbol{s}, a; x, \boldsymbol{z}, r) = \max_{c^f, c^m, l^f, l^m, a'} \Big\{ \mu(x, \boldsymbol{z}) U^f(c^f, l^f) + [1 - \mu(x, \boldsymbol{z})] U^m(c^m, l^m) + \beta \sum_{\boldsymbol{s'}} \pi_{\boldsymbol{s'}|\boldsymbol{s}} V(\boldsymbol{s'}, a'; x, \boldsymbol{z}, r) \Big\} \quad (1.2.9)$$

s.t.

$$c^f + c^m + a' = \sum_{i=f,m} w^i(1 - l^i)s^i + \sum_{i=f,m} (1 - s^i)b^i + (1 + r)a \quad (1.2.10)$$

$$c^f, c^m \geq 0, \quad 0 \leq l^f, l^m \leq 1, \text{ and } a' \in [\underline{a}, \bar{a}], \quad (1.2.11)$$

where $\pi_{\boldsymbol{s'}|\boldsymbol{s}}$ are the elements of Π. Note that while we allow for different preferences over consumption and leisure for females and males, we assume that both spouses share a common discount factor β. In our model, $\boldsymbol{z}$ is the only source of variation in Pareto weights across households. We represent the distribution of these weights in the population of households by $G(\mu)$. The support of this distribution is denoted by $M \equiv (0, 1)$.

Contrary to unitary models of the household, the utility function of the collective household depends, *via* the Pareto weight, on wages and policy variables, which leads to household demands that fail to meet the Slutsky conditions. This failure is the defining feature of the collective model. Also, while in unitary models household decisions do not depend on who receives the income within the household, in our collective model decisions depend on total income as well as on who receives the income (whether it is the female or the male).

The dependency of the household's utility function on prices and policy must also be acknowledged when setting the Frisch elasticities of labor supply for females and males. In particular, these elasticities are functions of the derivative of the Pareto weight with respect to wages. Our assumption that both labor supplies can vary continuously in response to wages and non-labor income is common in the literature of collective labor supply [see, e.g., Chiappori (1988) and Chiappori, Fortin and Lacroix (2002)].[6] Likewise, the household's attitude towards risk in the collective model depends both on individual preferences and on the relative Pareto weight. Since we will assume individual preferences which are not of the ISHARA type (i.e., household members do not share a common coefficient of harmonic risk-aversion), the household does not behave as a single decision maker, in the sense that an increase in risk aversion

[6] For a recent study of collective labor supply allowing for non continuity see Blundell, Chiappori, Magnac and Meghir (2007). These authors present a collective model of the household where the female makes a continuous labor supply choice but the male decides simply whether or not to participate.

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of one household member does not necessarily increase risk aversion of the household. [For an analysis of a two-period, collective model of the household with uncertainty see Mazzocco (2004)].

It should be noted that our assumption of egoistical preferences is not crucial. Actually, Browning, Chiappori and Lechene (2006) show that under caring preferences of the form where female's instantaneous utility is $U^f(c^f, l^f) + \psi^f U^m(c^m, l^m)$ and male's utility is $U^m(c^m, l^m) + \psi^m U^f(c^f, l^f)$, with $0 < \psi^f, \psi^m \leq 1$ denoting the caring parameters, the utility function of the household can be written down as for the case of egotistical preferences, after a re-definition of Pareto weights. The new relative weight on female's utility $U^f(c^f, l^f)$ would be $\hat{\mu} \equiv (\mu + (1-\mu)\psi^m)/(1 + \mu\psi^f + (1-\mu)\psi^m)$. Note that this weight converges to 0.5 as ψ^f and ψ^m converge to 1, for all values of μ.

We now present the first-order conditions to the maximization problem (2.9)-(2.11). As explained above, the collective model of the household implies full risk-sharing within the household, i.e., the ratio of marginal utilities of consumption equals relative Pareto weights and is thus independent of the realized vector of employment shocks. That is,

$$\mu U_c^f = (1-\mu) U_c^m. \tag{1.2.12}$$

This equation defines the individual risk-sharing rules, which, for a given level of household consumption, specify how much is consumed by each of its members. It is straightforward to show that the derivative of the risk-sharing rules is positive and given by the product of the household's coefficient of absolute risk aversion and the individual's coefficient of absolute risk tolerance.[7] Therefore, the member of the household showing higher risk tolerance will be the one absorbing most of the variation in total household consumption. (In Appendix IV we present the derivatives of the risk-sharing rules for the case of CRRA utility functions.)

First-order conditions to female and male labor supply are, respectively,

$$\frac{U_l^f}{U_c^f} \geq w^f s^f \qquad \text{with inequality if } l^f = 1 \tag{1.2.13}$$

$$\frac{U_l^m}{U_c^m} \geq w^m s^m \qquad \text{with inequality if } l^m = 1. \tag{1.2.14}$$

Moreover, if the labor supply decision is interior for both household members then

$$\frac{U_l^f}{w^f s^f} = \frac{1-\mu}{\mu} \frac{U_l^m}{w^m s^m}. \tag{1.2.15}$$

[7] Risk tolerance is defined as the reciprocal of risk aversion.

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The first-order condition to savings is,

$$U_c^f = \beta(1+r)\sum_{s'} \pi_{s'|s}\, U_c^{f\prime} \qquad \text{if } a' > \bar{a} \tag{1.2.16}$$

$$U_c^f \geq \beta(1+r)\sum_{s'} \pi_{s'|s}\, U_c^{f\prime} \qquad \text{if } a' = \underline{a}. \tag{1.2.17}$$

We can now present some properties of the value function and optimal decision rules for a household with Pareto weight $\mu \in M$. (We present the proofs for the case $b^f = b^m = 0$, but it is straightforward to show that the results hold for the case of positive benefits, provided $w^i l^i \geq b^i$ for $i = f, m$, i.e., earnings are higher than unemployment benefits.)

Proposition 1. Assume $\mathbf{A1} - \mathbf{A3}$, $\boldsymbol{w} > 0$, $(1+r) > 0$, $\beta(1+r) \leq 1$. Then:

(a) $V(\boldsymbol{s}, a, \mu)$ is strictly increasing and strictly concave in a. Decision rules $c^f(\boldsymbol{s}, a; \mu)$, $c^m(\boldsymbol{s}, a; \mu)$, $l^f(\boldsymbol{s}, a; \mu), l^m(\boldsymbol{s}, a; \mu)$ and $a'(\boldsymbol{s}, a; \mu)$ are continuous in a and strictly positive.

(b) Decision rules for consumption, $c^f(\boldsymbol{s}, a; \mu)$ and $c^m(\boldsymbol{s}, a; \mu)$, are strictly increasing in a. Decision rules for savings, $a'(\boldsymbol{s}, a; \mu)$, and leisure, $l^f(s^f = 1, s^m, a; \mu)$, $l^m(s^m = 1, s^f, a; \mu)$, are increasing in a.

(c) Decision rules for consumption are increasing in the own employment shock: $c^j(s^j = 1, s^i, a; \mu) \geq c^j(s^j = 0, s^i, a; \mu)$.

(d) Decision rules for leisure are increasing in the spouse's employment shock: $l^j(s^j = 1, s^i = 1, a) \geq l^j(s^j = 1, s^i = 0, a; \mu)$.

(e) If $\beta(1+r) \leq 1$, then for all $a \in [\underline{a}, \bar{a}]$, $a'(s^f = 0, s^m = 0, a; \mu) \leq a$ (with strict inequality if $\underline{a} < a < \bar{a}$ and $\beta(1+r) < 1$).

Proof: See the Appendix.

We now present some results on the asymptotic properties of the consumption program, savings and labor supply of a household with Pareto weight μ, for different values of wages, (w^f, w^m), and of the interest rate, r. More specifically, we extend results by Marcet, Obiols-Homs and Weil (2007) for the bachelor household to our two-person, collective household model. We also extend the results to non-homogeneous utility functions. With this aim, let us denote by $\tilde{a}(\mu)$ the minimum level of asset holdings for which both spouses within a household with Pareto weight μ will stop supplying labor. The value $\tilde{a}(\mu)$ is pinned down as follows. First, since utility is separable in consumption and leisure, we can plug (1.2.12) into

(1.2.14) and thus rewrite the first-order conditions to female and male labor supply as

$$U_c^f s^f \leq \frac{U_l^f}{w^f} \qquad \text{with inequality if } l^f = 1 \tag{1.2.18}$$

$$U_c^f s^m \leq \frac{U_l^m}{w^m}\frac{1-\mu}{\mu} \qquad \text{with inequality if } l^m = 1. \tag{1.2.19}$$

Define $\widetilde{U}_l^i$ as the marginal utility of leisure for individual $i = f, m$, at $l^i = 1$. Also, define

$$\widetilde{U}_c^f(\mu) \equiv \min\left\{\frac{\widetilde{U}_l^f}{w^f}\ ,\ \frac{\widetilde{U}_l^m}{w^m}\frac{1-\mu}{\mu}\right\} \tag{1.2.20}$$

and $\widetilde{U}_c^m(\mu) \equiv \frac{\mu}{1-\mu}\widetilde{U}_c^f(\mu)$. Let $\widetilde{c}^i(\mu)$ be the level of consumption for which the corresponding marginal utility of consumption equals $\widetilde{U}_c^i(\mu)$. Then the level of asset holding $\tilde{a}(\mu)$ mentioned above is defined as

$$\widetilde{a}(\mu) \equiv \frac{1}{r}\Big[\widetilde{c}^f(\mu) + \widetilde{c}^m(\mu)\Big]. \tag{1.2.21}$$

It can easily be checked that at $\widetilde{a}(\mu)$, equations (1.2.10) – (1.2.14) are satisfied for all possible realizations of s^f and s^m if consumption levels equal $\widetilde{c}^f(\mu)$ and $\widetilde{c}^m(\mu)$, hours worked equal zero and asset holdings remain constant. In the case that $\beta(1+r) = 1$, equation (1.2.16) is satisfied, because consumption is constant. Hence, if $\beta(1+r) = 1$, optimal decision rules are

$$c^i(\boldsymbol{s}, \widetilde{a}(\mu); \mu) = \widetilde{c}^i(\mu) \tag{1.2.22}$$

$$l^i(\boldsymbol{s}, \widetilde{a}(\mu); \mu) = 1 \tag{1.2.23}$$

$$a'(\boldsymbol{s}, \widetilde{a}(\mu); \mu) = \widetilde{a}(\mu), \tag{1.2.24}$$

for $i = f, m$ and for all $\boldsymbol{s} \in S \times S$. Thus, if the household ever reaches $\widetilde{a}(\mu)$, it will maintain a constant consumption stream without ever working. For lower interest rates, constant consumption does not satisfy the FOC for asset holdings, and the household never reaches $\widetilde{a}(\mu)$. The following proposition formalizes this result.

Proposition 2: Assume **A1** $-$ **A3**, $\overline{a} > \widetilde{a}(\mu)$, $\boldsymbol{w} > 0$ and $(1+r) > 0$. Then:

- **(a)** If $\beta(1+r) \leq 1$, for any $a \leq \widetilde{a}(\mu)$, $a'(\boldsymbol{s}, a; \mu) \leq \widetilde{a}(\mu)$.
- **(b)** If $\beta(1+r) = 1$, for any $a \geq \widetilde{a}(\mu)$ and any $\boldsymbol{s}$ we have $a'(\boldsymbol{s}, a; \mu) = a$, $l^f(\boldsymbol{s}, a; \mu) = 1$, $l^m(\boldsymbol{s}, a; \mu) = 1$ and $c^f(\boldsymbol{s}, a; \mu) + c^m(\boldsymbol{s}, a; \mu) = a\, r$ such that $\mu U_c^f = (1-\mu)\, U_c^m$.
- **(c)** If $\beta(1+r) = 1$ and $a \leq \widetilde{a}(\mu)$, then $a_t \xrightarrow{a.s.} \widetilde{a}(\mu), c_t^i \xrightarrow{a.s.} \widetilde{c}^i(\mu)$, $l_t^i \xrightarrow{a.s.} 1$, $i = f, m$.

Proof: See the Appendix.

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It follows that in the case $\beta(1+r) < 1$ the household can reach any value of asset holdings from any initial capital stock in finite time, and a stationary distribution arises in the long run. Moreover, in the case $\beta(1+r) = 1$ and $a \leq \widetilde{a}(\mu)$, capital accumulation in the long run is bounded and it converges asymptotically to $\widetilde{a}(\mu)$. This is in contrast to the case of inelastic labor supply where savings asymptotically grow to infinity if $\beta(1+r) = 1$. As it should be apparent from these results, the endogenous labor-leisure decision changes the asymptotic behavior of consumption and assets with respect to the inelastic labor case by removing income uncertainty. When household wealth is high enough, labor supply equals zero and thus employment shocks no longer affect household income. Hence, under non-stochastic income, unbounded asset accumulation is no longer optimal under $\beta(1+r) = 1$.

Finally, note that if we set $\overline{a} > \max_{\mu \in M} \widetilde{a}(\mu)$ and choose initial capital holdings for all households with relative Pareto weight μ such that $a_0(\mu) \leq \widetilde{a}(\mu)$, then the upper limit on capital is never binding. In other words, under these conditions the upper bound on asset holdings, which was imposed to guarantee existence and uniqueness of the value function, does not bind.

1.3 Stationary Equilibrium with Incomplete Markets

We define now a stationary equilibrium with incomplete markets in the collective household economy. Let $\psi(B;\mu)$ be a probability measure describing the mass of households with fixed Pareto weight μ at each point in the state space X, where $\psi(B;\mu)$ is defined on the Borel sigma algebra $\mathcal{B}$. Denote by $P(\boldsymbol{s}, a, B; \mu)$ the probability that a household with Pareto weight μ at state $(\boldsymbol{s}, a)$ will transit to a state that lies in $B \in \mathcal{B}$ in the next period. The transition function P can be constructed as

$$P(\boldsymbol{s}, a, B; \mu) = \sum_{\boldsymbol{s}' \in B_{\boldsymbol{s}}} \Pi_{\boldsymbol{s}'|\boldsymbol{s}} \, \mathcal{I}_{a'(\boldsymbol{s}, a; \mu) \in B_a},$$

where $\mathcal{I}$ is an indicator function taking on a value of 1 if its argument is true and 0 otherwise, and $B_{\boldsymbol{s}}$ and B_a are the projections of B on $S \times S$ and $[\underline{a}, \overline{a}]$ respectively. Note that these transition functions will in general differ across households with different Pareto weights μ. We are now ready to define the equilibrium concept for our model.

Definition: A stationary recursive competitive equilibrium with incomplete markets in the economy with collective households is a list of functions $\left\{V, c^f, c^m, l^f, l^m, a', K, L^f, L^m\right\}$, a measure of households ψ and a set of prices $\left\{r, \bar{w}^f, \bar{w}^m\right\}$, taxes $\left\{\tau^f, \tau^m\right\}$ and benefits $\left\{b^f, b^m\right\}$ such that:

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1) For given prices, taxes and benefits, V is the solution to (1.2.9) – (1.2.11), and $c^f(\boldsymbol{s}, a; \mu)$, $c^m(\boldsymbol{s}, a; \mu)$, $l^f(\boldsymbol{s}, a; mu)$, $l^m(\boldsymbol{s}, a; \mu)$ and $a'(\boldsymbol{s}, a; \mu)$ are the associated optimal policy functions.

2) For given prices, K, L^f and L^m satisfy the firm's first-order conditions (1.2.2) – (1.2.4).

3) Aggregate factor inputs are generated by the policy functions of the agents:

$$K = \int_M \int_X a'(\boldsymbol{s}, a; \mu) d\psi dG, \tag{1.3.1}$$

$$L^f = \int_M \int_X s^f [1 - l^f(\boldsymbol{s}, a; \mu)] d\psi dG, \tag{1.3.2}$$

$$L^m = \int_M \int_X s^m [1 - l^m(\boldsymbol{s}, a; \mu)] d\psi dG. \tag{1.3.3}$$

4) The time-invariant stationary distribution ψ is determined by the transition function P as

$$\psi(B; \mu) = \int_X P(\boldsymbol{s}, a, B; \mu) d\psi \quad \text{for all} \quad B \in \mathcal{B}. \tag{1.3.4}$$

5) The government budget is balanced: $q_0^f b^f + q_0^m b^m = \tau^f \bar{w}^f L^f + \tau^m \bar{w}^m L^m$.

Under assumptions $\mathbf{A1} - \mathbf{A3}$ the interest rate in the stationary equilibrium under incomplete markets must be such that $\beta(1+r) < 1$. This implies that the equilibrium capital-labor ratio under incomplete markets is higher than under complete markets.

1.3.1 Stationary Equilibrium with Complete Markets

In the complete markets economy households can trade a set of Arrow securities which pay contingent on the realization of the idiosyncratic shocks of both spouses.[8] It is then straightforward to show that in a stationary equilibrium the interest rate must be such that $\beta(1+r) = 1$. In addition, marginal utilities of consumption are equalized across states and periods, which in conjunction with assumption **A2** implies that female and male consumption levels are independent of the vector of the household's employment shocks $\boldsymbol{s} = (s^f, s^m)$ and constant over time. In a stationary equilibrium with complete markets the capital-labor ratio K/L and optimal household decision rules are uniquely determined, whereas the absolute values of K and L are not pinned down: in fact, there are infinitely many different distributions of households that generate pairs of aggregate capital K and aggregate labor L which are all consistent with the equilibrium capital-labor ratio. Hence, when comparing the stationary complete

[8] See Appendix II for a complete characterization of this economy.

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markets equilibrium with the incomplete markets economy, we must choose an equilibrium selection mechanism in the complete markets economy. An obvious candidate is the steady state equilibrium that arises after the transition from the incomplete markets economy. That is, when markets are completed, we compute the long-run equilibrium using the stationary equilibrium of the incomplete markets economy as initial conditions.[9]

1.3.2 Parameterization and Calibration

Parameterization

Preferences Instantaneous utility functions for females and males are parameterized as follows,

$$U^i(c,l) = \varphi_c^i \frac{c^{1-\sigma^i}-1}{1-\sigma^i} + \varphi_l^i \frac{l^{1-\gamma^i}-1}{1-\gamma^i} \quad \text{for} \quad i=f,m, \tag{1.3.5}$$

where φ_c^i and φ_l^i are parameters (φ_c^f is normalized to one) and σ^i is the coefficient of relative risk aversion of an individual of gender i. It must be noted that in the model with collective households —and contrary to the model with bachelor households— the Frisch elasticity of labor supply of an individual of gender i depends not only on parameter γ^i, but is also a function of variables and parameters that affect the expected, intrahousehold earnings differential through the Pareto weight (see Appendix III for a derivation of Frisch elasticities in the collective household economy). Also, as anticipated above, a household's risk aversion is determined by individual preferences for risk and by the household sharing rule μ. It is only when the two household members share the same preferences for risk, i.e., $\sigma^f = \sigma^m$, that the household's coefficient of relative risk aversion becomes independent of Pareto weights (see Appendix IV for a derivation of the household's coefficient of risk aversion).

Technology As written above, the production takes place according to the standard Cobb-Douglas technology, $F(K,L) = K^\alpha L^{1-\alpha}$, where labor is $L \equiv \lambda L^m + (1-\lambda)L^f$. Parameter α is the capital share of income and λ pins down relative gross wages, since $\overline{w}^f/\overline{w}^m = (1-\lambda)/\lambda$.

Pareto weights We will make the following simplifying assumption on the distribution of Pareto weights over the population, G. In our benchmark economy we assume that all households are ex-ante identical and have a relative Pareto weight equal to 0.5. This amounts to assuming a degenerate distribution over the vector $\boldsymbol{z}$ so that females and males have a Pareto weight exactly equal to 0.5 in all households. It should be noted, however, that a Pareto

[9] Pijoan-Mas (2006) contains a detailed description of the computational algorithm for an Aiyagari-Huggett economy without public insurance and with ex-ante identical, same-gender individuals.

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weight of 0.5 would endogenously arise under caring preferences of the form discussed above for high enough caring parameters ψ^f and ψ^m.

We also need the derivative of the Pareto weight function with respect to x, $\mu_1(x, \boldsymbol{z})$, in order to pin down the Frisch elasticities of labor supply. We will set the value of this derivative using empirical estimates of the sharing rule. We detail this empirical evidence and our procedure below.

Parameter Values

Our model contains eight preference parameters: $\beta, \varphi_c^m, \varphi_l^f, \varphi_l^m, \sigma^f$, σ^m, γ^f and γ^m. There are three technology parameters: α, λ and δ. The two transition matrices Π^f and Π^m contain four parameters. The parameter $\underline{a}$ defines the minimum level of asset holdings for any household, i.e. the borrowing limit. The public insurance program is described by tax rates and the level of unemployment benefits: τ^f, τ^m, b^f and b^m (one of the tax rates is determined from the balanced-budget constraint). Finally, we have to pin down the derivative of the Pareto weight function with respect to x, μ_1.

The length of a period in the model is set to one quarter. We will normalize φ_c^f to 1, which is equivalent to dividing both instantaneous utility functions by this parameter. The borrowing limit is set to zero, i.e. households are restricted to hold non-negative asset holdings at all times. In order to calibrate the remaining parameters we choose a set of statistics from aggregate and household survey data for the U.S. economy, such that the incomplete markets equilibrium of our collective household economy matches these targets. Using estimates for the quarterly capital depreciation rate and the capital share of income, we set $\delta = 0.025$ and $\alpha = 0.36$, which are both standard values in the macro literature.

In our benchmark economy, we impose equal labor income tax rates for females and males, $\tau^f = \tau^m$. Consequently, the value for λ can be pinned down using *a priori* information on the gender wage gap. We set this parameter equal to 0.575, which implies a ratio of female to male wages of 0.74. This corresponds to the gender wage gap in 2004 as reported by Heathcote, Storesletten and Violante (2010) for the U.S. economy.

Transition probabilities for idiosyncratic employment shocks are assumed to be identical for females and males. While the female unemployment rate averaged 1.5% percentage points higher than the male rate during the period 1960-1980, the female-male gap disappeared after the early 1980's. Even though male unemployment rates generally increase more than female rates during recessions —mainly due to the fact that men dominate industries like manu-

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facturing and construction— the average difference between female and male unemployment rates over the period 1980-2009 is practically zero. Explanations for the narrowing gap in unemployment rates point to the relative increase of service-oriented industries which employ a large proportion of women. We use the following transition probabilities which match an average employment rate of 93% after normalizing with the participation rate,[10]

$$\Pi^i = \begin{pmatrix} 0.09 & 0.91 \\ 0.06 & 0.94 \end{pmatrix} \quad \text{for } i = f, m. \tag{1.3.6}$$

Our assumption that within-household unemployment shocks are uncorrelated can be supported from SIPP data. Indeed, from the April 1996 panel of the Survey of Income and Program Participation, which covers 48 months between April 1996 and March 2000, it is possible to compute the within-household unemployment correlation. Since information on occupation is available in these data, unemployment correlations can be computed both for households where husband and wife report different occupation and for households reporting the same occupation. Within-household unemployment correlation in the first group is 0.05, and 0.23 in the second. It should be noted, however, that the fraction of households reporting same occupation for husband and wife is only 3.2% of the total. (For a detailed explanation on the calculation of these correlations, see Shore and Sinai 2010.)

The remaining twelve parameters are set such that our model matches the following targets:

1. Married females' average hours of work if working represent 28% of their discretionary time. Married males' average hours of work if working represent 40% of their discretionary time.[11]

2. Estimates for males' Frisch elasticity of labor supply in the presence of potentially binding borrowing constraints range from 0.2 to 0.6 (see Domeij and Flodén 2006). Blundell and MaCurdy (1999) find that for females this elasticity is 3-4 times larger than for males. We will target values of 0.37 and 1.2 for males and females, respectively.

3. Non-gender-based estimates of the average coefficient of relative risk aversion have yielded values ranging from 1 to 10. When gender is taken into account, females are

[10]These transition probabilities are similar to the ones used in the previous literature, see e.g. Imrohoroglu (1989), Krusell and Smith (1998) and Marcet, Obiols-Homs and Weil (2007).

[11]Mazzocco, Ruiz and Yamaguchi (2008) use PSID data from 1968 to 1996 to compute mean annual hours worked if working for married females and males; he finds values of 1660 and 2312 respectively. We make the assumption that the disposable daily time endowment is 16 hours.

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found to be more risk-averse than males.[12] We set individual preferences for risk at $\sigma^f = 2$ and $\sigma^m = 1.5$, which yields an average coefficient of relative risk aversion for the collective household of 1.68.

4. The capital-to-output ratio is around 10.

5. The ratio of annual hours worked by single working women to annual hours worked by single working men is $1861/2095 = 89$ percent.[13] We will match this value using the equilibrium of the bachelor economy.

6. The average net unemployment benefit replacement rate in the United States is roughly 30 percent (see OECD 2010). We will set b^f and b^m to match this target as fractions of the average wage income both for females and males. Labor income tax rates are set to balance the budget constraint of the government.

7. The derivative of the Pareto weight function with respect to the expected income differential, μ_1, is set to match the sharing rule estimates presented in Browning, Bourguignon, Chiappori and Lechene (1994).

As for the last target, Browning et al. (1994) use data on couples with no children to estimate the parameters of the sharing rule: they find that the wife's share in total expenditure increases modestly with her share in household income. Specifically, increasing the wife's contribution to household income from 25% to 75% (holding total expenditure constant) raises her share in total expenditure by about 2.3%. In addition, the impact of total expenditure on the wife's share is positive and sizable. For instance, an increase in total expenditures (holding her relative contribution to household income fixed) by 60% raises the wife's share by about 12%. We use these empirical estimates to ascertain the value of $\mu_1|_{\mu=0.5}$ as follows. Starting from the benchmark equilibrium and $\mu = 0.5$, we increase the value of x — e.g. by raising w^f/w^m — and then compute the new Pareto weight, say $\tilde{\mu}$, such that the implied increase in the wife's relative contribution to household income yields an increase in the wife's share of total expenditure, $c^f/(c^f + c^m)$, that matches the one implied by the sharing rule as estimated in Browning, Bourguignon, Chiappori and Lechene (1994).[14] Given the imputed value $\tilde{\mu}$, we then use a linear approximation to obtain $\mu_1|_{\mu=0.5}$.

Table 1 presents parameter values for our benchmark economy.

[12] For a recent study of risk aversion and gender see Maestripieri, Sapienza and Zingales (2009), who find a negative relation between testosterone levels and risk aversion.

[13] See Mazzocco, Ruiz and Yamaguchi (2008).

[14] When computing the wife's shares of income and expenditures, we take the average over all households.

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Table 1. Baseline Parameters

Description	Parameter	Value	Description	Parameter	Value
Female risk aversion	σ^f	2	Utility weight	φ_c^f	1
Male risk aversion	σ^m	1.5	Utility weight	φ_c^m	2.15
Frisch elasticity	γ^f	2	Utility weight	φ_l^f	2.662
Frisch elasticity	γ^m	3.75	Utility weight	φ_l^m	0.911
Pareto weight	μ	0.5	Discount factor	β	0.989
Derivative Pareto weight	μ_1	0.038	Unemployment benefits	b^f	0.083
Capital share	α	0.36	Unemployment benefits	b^m	0.161
Depreciation rate	δ	0.025	Relative wages	λ	0.575

1.3.3 Steady-state Equilibrium

Aggregate variables in the steady-state equilibrium with incomplete markets are presented in Table 2 below, both for the collective and the bachelor household economies. Note that the two economies differ only in the insurance opportunities available to individuals, and, therefore, differences in aggregates variables reflect the equilibrium effects of intrahousehold risk sharing. Aggregate capital is higher in the bachelor economy, as the lack of insurance from the family in this economy leads individuals to rely more on savings. Aggregate work effort by females and males rank differently in the two economies. While male labor is higher in the collective economy, females work more in the bachelor economy. In this latter economy, females are relatively poorer and, since they lack the consumption insurance provided by the family, must supply more hours of work. On the contrary, males finance part of female consumption in the collective economy (even with equal Pareto weights) and must therefore work longer hours. Total labor is higher in the bachelor household economy. We will elaborate further on this below. The capital-labor ratio is lower in the economy with intrahousehold risk sharing, yielding a higher interest rate as compared to the economy with bachelor households. Finally, production is higher in the economy with bachelor households, which results from larger aggregate capital and labor.

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Table 2. Steady-state equilibrium: Aggregate Variables

	Y	K	L	K/L	L^f	L^m	$1+r$
Collective household economy	1.2723	12.6820	0.3490	36.3351	0.2799	0.4001	1.1115
Bachelor household economy	1.3081	13.0410	0.3588	36.3452	0.3363	0.3754	1.1109

Notes: This table presents the steady-state equilibrium with incomplete markets in the economies with and without intrahousehold risk sharing.

Policy Functions

The relative contribution of households across the wealth and employment distribution to the differences in economic aggregates shown in Table 2 are now explored. Labor supply and saving policy functions of collective households are presented in Figures 1.1 and 3.1, respectively. The top panel of Figure 1.1 plots hours worked by females and males in households where the two spouses are employed. Hours decrease with household wealth, and the rate of decline is higher for females, implying that they work relatively less in asset-rich households. As asset holdings approach the borrowing limit, policy functions for hours bend upwards, capturing the fact that asset-poor households use labor supply to smooth consumption more intensively. Hours worked by females and males when the spouse is unemployed are plotted in the bottom panel of Figure 1.1 (for convenience, we plot them along with those emerging when the two spouses are employed). First, hours supplied increase if the spouse is unemployed, both for females and males, and the increase is especially marked for females in asset-poor households. For example, a female in a household with no assets will supply almost half of her available time to work if the spouse is unemployed, as opposed to 0.37 when the spouse is employed, which represents a decline of more than 25%. We now display the effects of intrahousehold risk sharing on hours worked at different levels of asset holdings and employment shocks. Figure 2.1 (top panel) plots excess hours worked by two bachelors (each with wealth $a/2$) over hours worked by a two-person collective household (with wealth a). For all households where only the male is employed, intrahousehold risk sharing increases household hours. For households where the female is employed, with the exception of low-wealth households with the male unemployed, intrahousehold risk sharing decreases household hours. The bottom panel of the Figure shows the average of these excess hours across households along the employment distribution. As it is apparent, the effects of intrahousehold risk sharing on hours are strongest among wealth-poor households.

Savings policy functions in the collective model are presented in Figure 3.1 (for convenience we plot the net change in asset holdings $a' - a$). Households where the two spouses are

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employed choose positive net savings at the borrowing limit and at all values in the support of the equilibrium distribution of assets. For households with at least one of the spouses unemployed, net savings are zero at the borrowing limit and negative for a large set of asset holdings. Negative net savings are larger in households where the male is unemployed. The saving effects of intrahousehold risk sharing at different levels of asset holdings are shown in Figure 4.1. The top panel of Figure 4.1 plots excess savings of two bachelors (each with wealth $a/2$) over a two-person collective household (with wealth a). The bottom panel plots the average of excess savings across employment shocks. Clearly, although risk sharing affects the savings decisions of all households across the wealth distribution, its effects are strongest among wealth-poor households.

1.3.4 Aggregate Precautionary Savings and Precautionary Labor Supply

We now move to assessing the consequences of completing markets, and to how these depend on the ability to share risks within the family. As already noted, aggregate precautionary savings in our framework are small, regardless of whether intrahousehold risk sharing is available or not. This is a consequence of our specification of the income process — employment/unemployment shocks coupled with unemployment benefits— which lacks the necessary persistence to generate large incentives to save for precautionary reasons. However, a comparison of precautionary savings and work effort across the economies with collective and bachelor households will help us assess the implications of intrahousehold risk sharing.

In Table 3 we present aggregate precautionary savings and precautionary labor supply in the collective model relative to those in the bachelor model. That is, we report $\Delta^{col.}/\Delta^{bach.}$, where Δ^i for $i = col., bach.$ denotes precautionary aggregates (savings and work effort) under households of type i. For our baseline parameter values, precautionary savings —measured as the fraction of capital held for precautionary motives— in the economy with collective households represent 55% of those in the economy with bachelor households. That is, access to insurance from the family reduces aggregate precautionary savings by 45%.

Aggregate precautionary work effort is equally measured by the fraction of hours worked for precautionary motives, i.e., $(L_{IM} - L_{CM})/L_{IM}$, where L_{IM} and L_{CM} denote hours worked under incomplete and complete markets, respectively. Both for females and males, aggregate work effort is higher in the complete markets economy, implying negative aggregate precautionary labor under both households arrangements. This is a consequence of an ex-post wealth effect operating in the incomplete markets economy. That is, conditional on being employed, individuals work relatively less hours in the incomplete markets economy because the inability to buy employment insurance makes them ex-post richer. Marcet, Obiols-Homs and Weil

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(2007) were the first to uncover the implications of this ex-post wealth effect for aggregate precautionary labor in the Aiyagari-Huggett model. In Table 3 we report precautionary labor in the collective household economy relative to that in the bachelor economy. The percentage increase in aggregate female labor resulting from completing markets in the collective household economy is only 37% of the increase under bachelor households. The increase in aggregate male labor represents 75% of the increase under bachelor households. That is, the ex-post wealth effect is weaker in the collective economy.

Table 3. Relative Precautionary Savings and Precautionary Work Effort

	K	L	L^f	L^m
$\Delta^{col.}/\Delta^{bach.}$	0.5552	0.5586*	0.3769*	0.7502*

Notes: $\Delta^i \equiv 1 - CM^i/IM^i$ for $i = col., bach.$, represent the fraction of capital held and hours worked for precautionary motives in an economy with households of type i. That is, CM^i and IM^i refer to aggregates under complete and incomplete markets, respectively. * For the case of aggregate labor, both $\Delta^{col.}$ and $\Delta^{bach.}$ are negative. I.e., both in the collective and the bachelor economies aggregate work effort is higher under complete markets than under incomplete markets.

1.4 Intrahousehold Risk Sharing and the Crowding-Out Effects of Unemployment Benefits

In our model economy there are two insurance mechanisms —in addition to public unemployment benefits— households can use to smooth consumption across unemployment spells: savings and labor supply. In the economy with intrahousehold risk sharing, spousal labor supply is a potentially important instrument to smooth consumption upon a spousal's unemployment spell. Changes in the level of public insurance call forth adjustments in the demand for other forms of insurance. The extent to which the ability to share risks within the household shapes the crowding out effects of public unemployment insurance is explored in this section.

1.4.1 Household Financial Assets and the Generosity of Unemployment Benefits

An implication of our model, as of any model with uninsurable income risk, is that household asset holdings increase with income uncertainty. Engen and Gruber (2001) exploit the variation in generosity of unemployment insurance schedules across U.S. states to test this implication and to estimate the extent of the precautionary savings motive. Since the level of unemployment benefits is directly correlated with household income risk, this variation can be used to measure the extent to which benefits crowd out household financial assets. These authors use data from the Survey of Income and Program Participation (SIPP) —which follows a cross section of households over a period of 2.5 years— in combination with data on unemployment benefits available to these households under their state/date benefits system. They regress household financial assets (normalized by average household income) on the generosity of benefits, controlling for a vector of demographic and economic characteristics of the household. The elasticity of the average household's financial assets-to-income ratio with respect to unemployment benefits is -0.28. That is, reducing the replacement rate of unemployment benefits by 50% raises the household's assets-to-income ratio by 14%.

In this subsection, we use our model economy to compute the elasticity of the average assets-to-income ratio with respect to unemployment benefits. The purpose of this exercise is twofold. On the one hand, we use it as a test for our model with collective households to match this estimated measure of the precautionary savings motive. On the other hand, we also compute this elasticity using the bachelor household model and assess by how much it overestimates the precautionary motive. In this latter model there is no intrahousehold risk sharing and, therefore, variation in unemployment benefits amounts to larger changes in household income risk and, consequently, to larger effects on savings.

In order to mimic the empirical exercise conducted by Engen and Gruber (2001) we proceed as follows. Since these authors rely on the exogenous variation in unemployment benefits for workers living in different states in the U.S., we interpret the level of unemployment benefits in our benchmark economy as the average value across all states. Then, we vary these benefits and compute asset-to-income ratios by solving the model keeping equilibrium prices unchanged, a strategy which is in accordance with the existence of a unique financial and labor market across states. However, Pareto weights and the distribution of households over asset holdings are let to change with unemployment benefits. Thus, our exercise compares the differential asset-to-income ratio of households across states that provide these households with differing unemployment benefits, which is exactly what Engen and Gruber (2001) do in their empirical work. The results of this exercise are presented in Table 4. As shown there, our collective household model accounts fairly well for the empirical elasticity estimated by Engen and Gruber (2001). On the contrary, the bachelor household model, which by construction abstracts from within-household risk sharing, overpredicts this elasticity by a factor of more than three. The economy with intrahousehold risk sharing yields an elasticity of the asset-income ratio of −0.29, against an elasticity of −0.94 in the bachelor household economy. Intrahousehold risk sharing plays thus a key role in the determination of the elasticity of the assets-to-income ratio with respect to benefits. This is evidence of the importance of this informal source of insurance when assessing the crowding out effects of public unemployment insurance.

The success of our collective model at matching this empirical elasticity, −0.29 in the model against −0.28 in the data, can be interpreted as providing support to the view that the two-person household embeds the most important informal insurance arrangement available to individuals. Indeed, some authors have emphasized the irrelevant insurance role played by the extended family, friends and other social networks (see, e.g., Blundell, Pistaferri and Preston 2008).

Table 4. Unemployment Benefits and Financial Assets

	Elasticity of average assets-to-income ratio w.r.t. replacement rate
Data (Engen and Gruber 2001)	−0.28
Collective Household Economy	−0.29
Bachelor Household Economy	−0.94

Notes: This table shows how household asset holdings respond to the generosity of unemployment benefits.

1.4.2 Spousal Labor Supply as Insurance

In the face of unemployment risk and capital market imperfections, spousal labor supply becomes a potential source of household self-insurance. The change in a household member's labor supply induced by an unemployment spell of another household member —the added worker effect— has been largely studied in the empirical literature. Most of this literature has focused on the labor supply response of married women to their husband's unemployment spells. The main argument in favor of restricting the attention to labor supply of women is that they are the secondary wage earners in most households (according to Cullen and Gruber 2000, in 87% of married couples in the U.S. the husband earns more and in 73% the husband works more hours).

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Early literature on the added worker effect (see Cullen and Gruber 2000 for a short review) has singled out liquidity constraints as one of the main reasons married women increase hours worked during their husband's unemployment spells. Empirical estimates have however produced mixed results, failing to find strong support for this effect.[15] Cullen and Gruber (2000), using data from the 1984-88 and 1990-92 panels of the Survey of Income Program Participation for married couples aged between 25 and 54 years old, report means for wives' monthly hours worked during husbands' spells of employment and unemployment, respectively. Conditional on working women, these authors find that the average amount of work per month of wives of unemployed husbands is 149 hours, as opposed to 132.4 hours worked by wives of employed husbands. When non working wives are included, i.e. those who work 0 hours, the change in average hours is small: 98.2 hours for wives with an unemployed husband, against 97.9 hours for those with an employed husband.

In this section we use our model economy with collective households to study the response of female labor supply to male's unemployment spells in two groups of households. In order to highlight the role of liquidity constraints on wives' labor supply responses, we follow Zeldes (1989) in defining a household as liquidity constrained if its non-housing wealth is less than two months of average income. Table 5 below reports the added worker effect in our model economy. For the group of liquidity-constrained households, average hours worked by wives of unemployed husbands are 8% higher than those worked by wives of employed husbands, an increase comparable to that found by Cullen and Gruber (2000) in their sample of working women. When all households are taken into account the increase in hours is only 0.06%. That is, spousal labor supply is an important insurance mechanism for wealth-poor households but not for the wealth rich.

Table 5. Female Labor Supply and Male Employment Status

	Households with wealth less than two months worth of income	All households
Employed Husband	173.1	145.1
Unemployed Husband	187.8	145.9

Notes: This table shows average monthly hours of work by working females in households with employed and unemployed males in our baseline economy with collective households.

[15]Stephens (2002) estimates the added worker effect taking into account not only the current period of the husband's job loss but also the periods before and after a job loss. This author finds small pre-displacement effects but large, persistent post-displacement effects.

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How effective is wives' labor supply as insurance against income fluctuations due to husbands' unemployment? In other words, what is the fraction of lost family income that is made up by the wife's response to the husband's unemployment spell? To answer this question we compute, for each level of asset holdings, a, the following fraction,

$$\frac{[h^f(0,1,a) - h^f(1,1,a)]w^f}{h^m(1,1,a)w^m - b^m},$$

where $h^f(0,1,a)$ denotes hours worked by a female with an unemployed husband and $h^f(1,1,a)$ denotes female hours worked if the husband is employed. The denominator represents lost income due to husband's unemployment. The numerator is the increase in income due to the wife's response in hours. We then average out across asset holdings. For the group of liquidity-constrained households (i.e., with asset holdings less than two months worth of income) we obtain that wives' response makes up about 9% of lost family income, while this number is only 1% when we consider all households. Households with high levels of asset holdings use savings to smooth consumption upon husband's unemployment rather than using spouse labor supply. Liquidity-constrained households must rely, however, on spousal labor supply.

Spousal Labor Supply and the Generosity of Unemployment Benefits

Some authors have argued that the finding of a moderate to nil added worker effect may be partially explained by the presence of public unemployment insurance schemes. That is, unemployment payments during the husband's unemployment spell crowd out wife's labor supply. To quantify this effect, Cullen and Gruber (2000) estimate the response in wives' hours of work during their husbands' spells of unemployment to changes in unemployment benefits. They find evidence of a crowd out effect, i.e., increasing the benefits received by unemployed husbands reduces their wives' hours of work. Moreover, they also find a differentially larger response of wives' labor supply among those households that are less able to smooth consumption through own savings.

We use our model economy to compute the crowding out of unemployment benefits on wives' labor supply. Table 6 below presents the results of this exercise. A 50% reduction in unemployment benefits received by the husband increases wife's hours by almost 5% for the group of liquidity-constrained households. This increase is only 0.71% when all households are considered. The relatively higher sensitivity of spousal labor supply to unemployment benefits among liquidity-constrained households found in our model in is line with the finding of Cullen and Gruber (2000).[16]

[16] In order to compare the relative responsiveness of couples with differing levels of assets these authors split

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Table 6. Unemployment Benefits and Female Labor Supply During Male's Unemployment Spells

	Households with wealth less than two months worth of income	All households
10% reduction in b^m	+0.91%	+0.14%
50% reduction in b^m	+4.97%	+0.71%

Notes: This table shows the percentage increase in female labor supply upon a male's unemployment spell yielded by 10% and 50% reductions in unemployment benefits in our baseline economy with collective households.

Even though a direct comparison of our results with those estimated by Cullen and Gruber (2000) is not straightforward, it seems that our model underpredicts the crowding out effect of unemployment benefits on spouse labor supply. According to their estimates, a 50% reduction in potential unemployment benefits of the husband (75 USD per week) would imply an increase in monthly hours worked by the wife (conditional on working) of 13.42 hours, which amounts to an increase of about 9%. Our model predicts that a 50% reduction in benefits receipt increases spouse labor supply, in the group of liquidity-constrained households, by 5%. It should be noted however that the estimate in Cullen and Gruber is not statistically significant, thus hindering the assessment of our model's predictions.

1.4.3 Consumption Loss Upon Unemployment

The loss of the job implies, under imperfect capital markets, a reduction in the level of individual consumption. In the case of complete markets, there is no consumption loss upon an unemployment shock. In the opposite extreme case of bachelor individuals with no assets, unable to borrow and with no entitlement to unemployment benefits, the consumption loss is one hundred percent. In intermediate cases with partial insurance, the degree of transmission of unemployment shocks to consumption depends on factors such as the generosity of unemployment benefits, on the level of accumulated wealth and on whether risks are shared within the household.

In this section we use our benchmark economy to assess the contribution of intrahousehold risk sharing to individual consumption insurance, as measured by the degree of transmission of unemployment shocks to consumption. We do so by comparing individual consumption

their sample of unemployment spells according to the age of the couple. Then, they interpret that households where the two spouses are under 40 years of age are liquidity constrained.

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losses upon unemployment in the collective household model to those in the bachelor model. We compute the percentage change in consumption upon unemployment, $\triangle c/c$, for all asset holdings in the support of the corresponding equilibrium distribution. In the collective economy, individual consumption losses for females and males, both with an employed spouse and with an unemployed spouse, are computed as,

$$-\frac{c^j(s^j=1,s^i,a)-c^j(s^j=0,s^i,a)}{c^j(s^j=1,s^i,a)}$$

for $j=f,m$, $i=f,m$ and $i\neq j$, both for $s^i=1$ and $s^i=0$. For the bachelor economy, individual consumption losses upon unemployment are simply computed as, $-(c^j(1,a)-c^j(0,a))/c^j(1,a)$ for $j=f,m$.

In Table 7 we report average individual consumption losses, both for the group of liquidity-constrained individuals and for all individuals. We use the respective equilibrium asset and employment distributions to average out individual consumption losses. The results show that intrahousehold risk sharing provides important consumption smoothing opportunities, especially for liquidity-constrained individuals. Thus, the average consumption loss for a liquidity-constrained female in the bachelor economy is -19.81%, against only -2.84% in the collective economy, which is eight times smaller. For a liquidity-constrained male, intrahousehold risk sharing reduces the consumption loss from -29.28% to -6.41%. These numbers imply that the family is an important provider of consumption insurance for a significant fraction of individuals.

Table 7. Individual consumption loss upon unemployment

	Collective Model		Bachelor Model	
	Liquidity-constrained individuals	All individuals	Liquidity-constrained individuals	All individuals
Females, $\triangle c^f/c^f$	−2.84%	−0.13%	−19.81%	−0.35%
Males, $\triangle c^m/c^m$	−6.41%	−0.32%	−29.28%	−0.57%

Notes: This table presents individual insurance as measured by the percentage of consumption lost upon an unemployment shock.

We now study household insurance by computing the fraction of income loss (due to an unemployment shock) that translates into consumption loss. To do this we compute income and consumption losses upon an unemployment shock for each household across the asset

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and employment distributions. Then, we average out the percentage of income loss that is transmitted to consumption loss across all households. Table 8 presents our results under the two household arrangements.

Table 8. Fraction of income loss that transmits to consumption loss

	Households with wealth less than two months worth of income	All households
Collective Household Economy	11.43%	0.66%
Bachelor Household Economy	32.82%	0.74%

Notes: This table presents household insurance as measured by the degree of transmission of the income loss to consumption upon an unemployment shock.

It should be noted that, even in the collective household economy, the fraction of income loss that transits to consumption loss in the group of liquidity-constrained households is non-negligible. For an average household in this group, 11.43% of the household income lost due to an unemployment shock is absorbed by consumption. This result is consistent with the empirical finding of Blundell, Pistaferri and Preston (2008) about the degree of insurability of transitory income shocks. These authors find that the impact of these shocks on consumption is small when estimated from all households in their sample, but it is found to be larger in the subsample of wealth-poor households (these authors define a household as wealth poor if its wealth in the first year this household is observed is in the bottom 20 percent of the distribution of initial wealth). Their estimate of the degree of partial insurance of temporary shocks in the sample of low-wealth households is close to 0.2.

Consumption Loss and the Generosity of Unemployment Benefits

We now turn to the sensitivity of household consumption losses upon unemployment with respect to the generosity of unemployment benefits, and assess the extent to which our model economy with collective households matches the empirical findings of Browning and Crossley (2001). These authors use a Canadian panel data set to estimate how changes in household consumption following a job loss vary with the generosity of unemployment benefits. Their empirical exercise exploits legislative changes to the unemployment insurance system introduced in 1993 and 1994, which reduced the replacement rate by about five percentage points. In total, $19,000$ individuals who had experienced a job separation either before or after the policy reform where interviewed several times after the job loss. Browning and Crossley (2001) obtain two main results. First, the level of unemployment benefits has small average effects on household consumption loss upon unemployment. In particular, a 10 percentage-point reduction in benefits leads to an average fall in consumption of 0.8%.[17] Second, the consumption effects of unemployment benefits are not homogeneous across households. For instance, for the sub-sample of liquidity-constrained households at the time of job separation these effects are substantially larger. (These authors also follow Zeldes (1989) in defining a household as liquidity-constrained if its non-housing wealth is less than two months of average disposal income.) These results show the importance of unemployment benefits as a consumption smoothing instrument for a large number of households. They also highlight the importance of carrying out analyses which go beyond the representative agent model and thus beyond estimating mean effects.

Table 9 below presents the elasticities of consumption loss with respect to unemployment benefits in our model economy with and without intrahousehold risk sharing, and compares the results to the estimates in Browning and Crossley (2001). Our quantitative exercise explicitly acknowledges the panel dimension of the empirical exercise conducted by these authors. We compute the relative change in consumption from the period prior to the unemployment shock to the period in which the job separation is realized. Saving household decisions in the pre-unemployment period are used for the computation of consumption when the unemployment shock hits. That is, consumption of an individual of gender j in the period before unemployment is $c^j(s^j = 1, s^i, a)$ and consumption at the time of the job loss is $c^j(s^j = 0, s^i, a')$, where $a' = a'(s^j = 1, s^i, a)$. We then weigh consumption levels in both periods using the stationary distribution of employment shocks for the spouse (in the collective economy). Our collective household economy accounts well for the elasticity of consumption loss with respect to benefits in the group of liquidity-constrained households. It however underestimates this elasticity for the whole sample of households.

[17] Gruber (1997) uses U.S. data on food consumption from the Panel Study of Income Dynamics (PSID) and finds a larger mean effect of unemployment benefits on consumption losses upon unemployment. This author estimates that a 10 percentage-point increase in benefits reduces the fall in consumption by 2.65%.

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Table 9. Elasticity of Household Consumption Loss to Unemployment Benefits

	Households with wealth less than two months worth of income	All households
Data (Browning and Crossley 2001)	−0.0922	−0.05
Collective Household Economy	−0.0827	−0.0013
Bachelor Household Economy	−0.2044	−0.0024

Notes: This table presents the sensitivity of household consumption loss upon unemployment with respect to the generosity of unemployment benefits.

It is important to note that estimates by Browning and Crossley (2001) of the elasticity of household consumption loss upon unemployment with respect to unemployment benefits use Canadian data, while our baseline parameter values have been chosen to match some U.S. stylized facts. Since it is likely that this elasticity differs when evaluated at U.S. equilibrium values, our exercise in this section should not be taken as an attempt at matching the estimated Canadian elasticity. It serves, however, to shed further light on the role of intrahousehold risk sharing. The elasticity predicted by the bachelor economy, 0.2044, is more than two times the elasticity under collective households.

1.5 Concluding Remarks

In this paper we assess quantitatively the effects of intrahousehold risk sharing on savings and labor supply within a model of idiosyncratic unemployment risk. With this purpose, we present a model economy where households are formed by a female and a male, who make collective decisions and lack access to a complete capital market. Our model is a dynamic version of the standard collective model of the household developed by Chiappori and co-authors since the 1980's, which assumes efficient risk sharing within the household. Equipped with this model, we then ask about the quantitative effects of this informal insurance arrangement on individual and aggregate savings and labor supplies, on the extent of the precautionary motive and on the crowding out effects of public insurance. In light of our results, we conclude that intrahousehold risk sharing has large quantitative effects on all these margins explored. Importantly, we find that our model economy accounts for key elasticities of savings and spousal labor supply with respect to unemployment benefits, as estimated by Engen and Gruber (2001) and Cullen and Gruber (2000), respectively. We also

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show that standard models, which abstract from intrahousehold risk sharing, fail to match those elasticities. A conclusion we draw from the exercise in this paper is that ignoring risk sharing at the level of the household introduces an important bias not only on the extent of the precautionary motive but also on the distortionary effects of public insurance programs.

The model we present in this paper can be used to address a number of related questions. In particular, we plan to use versions of this model to shed further light on a recent debate about gender-based taxation. A number of scholars have argued in favor of taxing females and males differently on the grounds of their different elasticities of labor supply. The interplay of income tax rates with Pareto weights within the household is bound to introduce tradeoffs that have been so far overlooked in this debate. A different extension that is worth pursuing is the consideration of permanent income shocks when household members have no-commitment to future household allocations. Under no commitment, variability in Pareto weights is magnified relative to the commitment case. It is then to be expected that the quantitative effects of intrahousehold risk sharing we found in this paper increase under the assumption of no-commitment. Finally, in light of recent results on the degree of household insurability against different types of shocks and the evolution of consumption and income inequality (see, e.g., Blundell, Pistaferri and Preston 2008), we need models that can account for the observed ability of households to insure different kinds of risks. Models with two-person households and perfect risk sharing within the household are a first step in this direction.

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1.6 Appendix I: Proofs

Proof of Proposition 1:

(a) The proof of this part follows from the Contraction Mapping Theorem and Theorem 3 and Corollary 2 in Denardo (1967).

(b) Case 1: We consider first values of a such that $a'(\boldsymbol{s}, a) > \underline{a}$ (interior solution).

(i) $c^f(\boldsymbol{s}, a)$, $c^m(\boldsymbol{s}, a)$ are strictly increasing in a. Take the envelope condition (using **A2**):

$$V_a(\boldsymbol{s}, a; \mu) = \mu U_c^f(c^f(\boldsymbol{s}, a), \cdot)(1+r) = (1-\mu)U_c^m(c^m(\boldsymbol{s}, a), \cdot)(1+r). \tag{1.6.1}$$

Since $V(\boldsymbol{s}, a, \mu)$ is strictly concave, $V_a(\boldsymbol{s}, a; \mu)$ is strictly decreasing in a. It follows that $U_c^i(c^i(\boldsymbol{s}, a; \mu), \cdot)$, $i = f, m$, must be strictly decreasing in a as well. Since U^i is strictly concave in c^i, the result follows.

(ii) $a'(\boldsymbol{s}, a)$ increasing in a. By contradiction: suppose there were values a_1, a_2 such that $a_2 > a_1$ and $a'(\boldsymbol{s}, a_2) < a'(\boldsymbol{s}, a_1)$. Then since $c^f(\boldsymbol{s}, a)$ is strictly increasing in a (as shown before), it has to be that $c^f(\boldsymbol{s}, a'(\boldsymbol{s}, a_2)) < c^f(\boldsymbol{s}, a'(\boldsymbol{s}, a_1))$. As utility is separable and the marginal utility of consumption does not depend on the level of leisure, the following holds:

$$\beta(1+r)E\left[U_c^f(c^f(\boldsymbol{s}', a'(\boldsymbol{s}, a_2)), \cdot)\right] > \beta(1+r)E\left[U_c^f(c^f(\boldsymbol{s}', a'(\boldsymbol{s}, a_1)), \cdot)\right].$$

However, the Euler equation then implies $U_c^f(c^f(\boldsymbol{s}, a_2), \cdot) > U_c^f(c^f(\boldsymbol{s}, a_1), \cdot)$, which is a contradiction because $c^f(\boldsymbol{s}, a_2) > c^f(\boldsymbol{s}, a_1)$.

(iii) $l^f(s^f = 1, s^m, a)$ and $l^m(s^m = 1, s^f, a)$ increasing in a. Intratemporal optimality requires:

$$\frac{U_l^i}{U_c^i} \geq w^i s^i, \quad \text{for } i = f, m, \tag{1.6.2}$$

with inequality if $l^i = 1$. Since $c^i(\boldsymbol{s}, a)$ is strictly increasing in a, $U_c^i(c^i(\boldsymbol{s}, a), \cdot)$ is strictly decreasing in a. Hence, $U_l^i(\cdot, l^i(s^i = 1, s^j, a))$ has to be decreasing in a, too. This implies that $l^i(s^i = 1, s^j, a)$ is increasing in a.

Case 2: Consider now values of a such that $a'(\boldsymbol{s}, a) = \underline{a}$ (non-interior solution).

In this case the budget constraint reads

$$c^f(\boldsymbol{s}, a) + c^m(\boldsymbol{s}, a) = w^f(1 - l^f(\boldsymbol{s}, a))s^f + w^m(1 - l^m(\boldsymbol{s}, a))s^m + (1+r)a - \underline{a}. \tag{1.6.3}$$

The proof is by contradiction:

(i) Suppose that $l^f(\boldsymbol{s},a)$ is decreasing in a and $l^m(\boldsymbol{s},a)$ is increasing in a. From intratemporal optimality (1.6.2) it follows that $c^f(\boldsymbol{s},a)$ must be decreasing in a and that $c^m(\boldsymbol{s},a)$ must be increasing in a. This is a contradiction with (1.2.12).

(ii) Suppose that $l^f(\boldsymbol{s},a)$ is increasing in a and $l^m(\boldsymbol{s},a)$ is decreasing in a. From intratemporal optimality (1.6.2) it follows that $c^f(\boldsymbol{s},a)$ must be increasing in a and that $c^m(\boldsymbol{s},a)$ must be decreasing in a. This is a contradiction with (1.2.12).

(iii) Suppose that $l^f(\boldsymbol{s},a)$ and $l^m(\boldsymbol{s},a)$ are decreasing in a. From intratemporal optimality (1.6.2) it follows that $c^f(\boldsymbol{s},a)$ and $c^m(\boldsymbol{s},a)$ must be decreasing in a. This is a contradiction with (1.6.3).

Hence, $l^f(\boldsymbol{s},a)$ and $l^m(\boldsymbol{s},a)$ are increasing in a, and (1.6.3) implies that c^f and c^m are strictly increasing in a.

(c) Case 1: Consider values of a such that $a'(\boldsymbol{s},a) > \underline{a}$ (interior solution).

As in the proof of Lemma 1 in Huggett (1993), it can be shown by induction that $V_a(s^j = 1, s^i, a) \leq V_a(s^j = 0, s^i, a)$, $\forall s^i$, using the assumption that $\pi^i_{1|1} \geq \pi^i_{1|0}$. The result then follows immediately from the envelope condition (1.6.1).

Case 2: We consider now values of a such that $a'(\boldsymbol{s},a) = \underline{a}$ (non-interior solution).

First we show that $c^j(s^j = 1, s^i = 0, a) \geq c^j(s^j = 0, s^i = 0, a)$. Evaluating the budget constraint at these two household's employment shocks we obtain,

$$\begin{aligned} &c^j(s^j=1,s^i=0,a)+c^i(s^j=1,s^i=0,a)+\underline{a}-(1+r)a-w^j(1-l^j(s^j=1,s^i=0,a))=0 \\ &c^j(s^j=0,s^i=0,a)+c^i(s^j=0,s^i=0,a)+\underline{a}-(1+r)a=0. \end{aligned} \tag{1.6.4}$$

This implies that $c^j(s^j = 1, s^i = 0, a) + c^i(s^j = 1, s^i = 0, a) \geq c^j(s^j = 0, s^i = 0, a) + c^i(s^j = 0, s^i = 0, a)$. The result follows from the first-order condition for consumption, (1.2.12).

We now show that $c^j(s^j = 1, s^i = 1, a) \geq c^j(s^j = 0, s^i = 1, a)$. Using the budget constraint and eliminating terms we get,

$$\begin{aligned} &c^j(s^j=s^i=1,a)+c^i(s^j=s^i=1,a)-w^i(1-l^i(s^j=s^i=1,a))-w^j(1-l^j(s^j=s^i=1,a)) \\ =\;&c^j(s^j=0,s^i=1,a)+c^i(s^j=0,s^i=1,a)-w^i(1-l^i(s^j=0,s^i=1,a)). \end{aligned} \tag{1.6.5}$$

Suppose, towards a contradiction, that $c^i(s^j = 1, s^i = 1, a) < c^i(s^j = 0, s^i = 1, a)$. Intratemporal optimality (1.6.2) then requires $l^i(s^j = 0, s^i = 1, a) > l^i(s^j = 1, s^i = 1, a)$, and (1.2.12) implies $c^j(s^j = 1, s^i = 1, a) < c^j(s^j = 0, s^i = 1, a)$. Hence, the right hand side of equation

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(1.6.5) is strictly larger than the first three terms on the left hand side, which immediately leads to a contradiction.

(d) Start from $c^j(s^j = 1, s^i, a) \geq c^j(s^j = 0, s^i, a), \forall a$. Then (1.2.12) implies that $c^i(s^j = 1, s^i, a) \geq c^i(s^j = 0, s^i, a)$. The result follows immediately from equations (1.2.13) and (1.2.14).

(e) By contradiction: suppose there is an $a \in [\underline{a}, \overline{a}]$ such that $a'(s^f = 0, s^m = 0, a) > a$ and

$$U_c^i(c^i(s^f = 0, s^m = 0, a), \cdot) = \beta(1+r)E\left[U_c^i(c^i(\boldsymbol{s}', a'(s^f = 0, s^m = 0, a)), \cdot)\right], \quad i = f, m.$$

(The equality follows from $a'(s^f = 0, s^m = 0, a) > a \geq \underline{a}$.) Since (i) $\beta(1+r) \leq 1$, (ii) $c^i(\boldsymbol{s}, a)$ strictly increasing in a and (iii) $c^i(\boldsymbol{s}, a)$ is time-invariant if factor prices are constant, it follows that:

$$\beta(1+r)E\left[U_c^i(c^i(\boldsymbol{s}', a'(s^f = 0, s^m = 0, a)), \cdot)\right] \leq E\left[U_c^i(c^i(\boldsymbol{s}', a), \cdot)\right].$$

Combining these two expressions implies that

$$U_c^i(c^i(s^f = 0, s^m = 0, a), \cdot) \leq E\left[U_c^i(c^i(\boldsymbol{s}', a), \cdot)\right].$$

Using part (c) this can only hold if $c^i(\boldsymbol{s}, a)$ is the same for all $\boldsymbol{s} \in S \times S$ and, consequently, $a'(\boldsymbol{s}, a) > a$ for all $\boldsymbol{s}$. Since consumption is strictly increasing in a, this implies that future consumption will be strictly higher in any state $\boldsymbol{s}'$ and, hence,

$$U_c^i(c^i(\boldsymbol{s}, a), \cdot) > E\left[U_c^i(c^i(\boldsymbol{s}', a'(\boldsymbol{s}, a)), \cdot)\right].$$

The Euler equation, however, requires

$$U_c^i(c^i(\boldsymbol{s}, a), \cdot) = \beta(1+r)E\left[U_c^i(c^i(\boldsymbol{s}', a'(s, a)), \cdot)\right],$$

which is impossible for $\beta(1+r) \leq 1$.

Strict inequality: suppose there is an $a \in (\underline{a}, \overline{a})$ such that $a'(s^f = 0, s^m = 0, a) = a$. Using part (c) it follows that $a'(\boldsymbol{s}, a) \geq a$ for all $\boldsymbol{s}$. Since consumption is strictly increasing in a, this implies that future consumption will be at least as high as current consumption in any state s' and, hence,

$$U_c^i(c^i(s^f = 0, s^m = 0, a), \cdot) \geq E\left[U_c^i(c^i(\boldsymbol{s}', a'(s^f = 0, s^m = 0, , a)), \cdot)\right].$$

The Euler equation, however, requires

$$U_c^i(c^i(s^f = 0, s^m =, a), \cdot) = \beta(1+r)E\left[U_c^i(c^i(\boldsymbol{s}', a'(s^f = 0, s^m = 0, a)), \cdot)\right],$$

(the equality follows from $a'(s^f = 0, s^m = 0, a) = a > \underline{a}$). This is impossible for $\beta(1+r) < 1$.

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Proof of Proposition 2:

In order to compact notation, we will write $\tilde{a}(\mu)$ simply as $\tilde{a}$.

(a) Let us first assume $r > 0$. We prove that $a'(\boldsymbol{s}, \widetilde{a}) \leq \widetilde{a}$. The result then follows from the fact that $a'(\boldsymbol{s}, a)$ is increasing in a, as shown before. From part (c) of Proposition 1, $a'(s^f = 0, s^m = 0, \widetilde{a}) \leq \widetilde{a}$. Then using the budget constraint:

$$a'(s^f = 0, s^m = 0, \widetilde{a}) \leq \widetilde{a} \quad (1.6.6)$$

$$w^f \cdot \Big(1 - l^f(s^f = 0, s^m = 0, \widetilde{a})\Big) \cdot 0 + w^m \cdot \Big(1 - l^m(s^f = 0, s^m = 0, \widetilde{a})\Big) \cdot 0$$
$$+(1+r)\widetilde{a} - c^f(s^f = 0, s^m = 0, \widetilde{a}) - c^m(s^f = 0, s^m = 0, \widetilde{a}) \leq \widetilde{a} \quad (1.6.7)$$

$$c^f(s^f = 0, s^m = 0, \widetilde{a}) + c^m(s^f = 0, s^m = 0, \widetilde{a}) \geq r\widetilde{a} \quad (1.6.8)$$

From before we know that decision rules for consumption are increasing in endowments; hence,

$$c^f(\boldsymbol{s}, \widetilde{a}) + c^m(\boldsymbol{s}, \widetilde{a}) \geq r\widetilde{a} \ , \qquad \forall \boldsymbol{s}.$$

Finally, use the definition of $\widetilde{a}$ from above and the FOC with respect to leisure to get

$$l^f(\boldsymbol{s}, \widetilde{a}) = l^m(\boldsymbol{s}, \widetilde{a}) = 1 \ , \qquad \forall \boldsymbol{s}.$$

Hence, $a'(\boldsymbol{s}, \widetilde{a}) \leq \widetilde{a}$.

Case $r \leq 0$: Take $a_1 < a_2$ and thus $c^f(\boldsymbol{s}, a_1) + c^m(\boldsymbol{s}, a_1) < c^f(\boldsymbol{s}, a_2) + c^m(\boldsymbol{s}, a_2)$. Plug in the budget constraints:

$$\begin{aligned} & w^f(1 - l^f(\boldsymbol{s}, a_1))s^f + w^m(1 - l^m(\boldsymbol{s}, a_1))s^m + (1+r)a_1 - a'(\boldsymbol{s}, a_1) \quad < \\ & w^f(1 - l^f(\boldsymbol{s}, a_2))s^f + w^m(1 - l^m(\boldsymbol{s}, a_2))s^m + (1+r)a_2 - a'(\boldsymbol{s}, a_2) \end{aligned} \quad (1.6.9)$$

and thus

$$a'(\boldsymbol{s}, a_2) - a'(\boldsymbol{s}, a_1) < (1+r)(a_2 - a_1) + w^f(l^f(\boldsymbol{s}, a_1) - l^f(\boldsymbol{s}, a_2))s^f + w^m(l^m(\boldsymbol{s}, a_1) - l^f(\boldsymbol{s}, a_2))s^m.$$

Divide by $a_2 - a_1$:

$$\frac{a'(\boldsymbol{s}, a_2) - a'(\boldsymbol{s}, a_1)}{a_2 - a_1} < (1+r) + \frac{1}{a_2 - a_1}\Big[w^f(l^f(\boldsymbol{s}, a_1) - l^f(\boldsymbol{s}, a_2))s^f + w^m(l^m(\boldsymbol{s}, a_1) - l^f(\boldsymbol{s}, a_2))s^m\Big].$$

Since leisure is increasing in a, the last two terms are non-positive. Also, r is non-positive by assumption. Therefore,

$$\frac{a'(\boldsymbol{s}, a_2) - a'(\boldsymbol{s}, a_1)}{a_2 - a_1} < 1.$$

That is, the decision rule for capital accumulation has a slope that is strictly lower than 1 and strictly positive. This implies that for all s there is a level of asset holdings $\widetilde{a}(s)$ (this is not the same $\widetilde{a}$ as above!) such that $a'(\boldsymbol{s}, \widetilde{a}) \leq \widetilde{a}$, i.e. a' crosses the 45 degree line at most once.

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(b) Take an arbitrary level of asset holdings $a_0 \geq \widetilde{a}$ and check whether the proposed allocation $\left\{\widehat{c}^f, \widehat{c}^m, \widehat{l}^f, \widehat{l}^m, \widehat{a}'\right\}$ satisfies first-order optimality:

- equation (1.2.12) is satisfied by definition

- $\widehat{c}^f + \widehat{c}^m = a\,r \geq \widetilde{a}\,r = \widetilde{c}^f + \widetilde{c}^m$; moreover, $\widehat{c}^i \geq \widetilde{c}^i \Longrightarrow \widehat{U}_c^i \leq \widetilde{U}_c^i$, $i = f, m$, which implies by (1.2.20) that equations (1.2.13) and (1.2.14) are satisfied

- the budget constraint (1.2.10) holds and

- the Euler equation (1.2.16) holds because consumption is constant.

Since the problem is concave, first-order optimality is sufficient for an optimum. Since the policy functions characterize the optimum, the proposed allocation is optimal.

(c) The proof exploits results in Chamberlain and Wilson (2000), which are also used in Marcet, Obiols-Homs and Weil (2007). Part (a) implies that $a_t \leq \widetilde{a}(\mu)$, $\forall t$, and part (b) of Proposition 1 together with part (b) of Proposition 2 imply that $c_t^i \leq \widetilde{c}^i(\mu)$, $i = f, m$, so that individual consumption levels are bounded almost surely. The first-order condition to savings (1.2.16) and (1.2.17) imply that $U_{c,t}^i \geq E_t(U_{c,t+1}^i)$ almost surely, so that $U_{c,t}^i$ is a super-martingale. As $U_{c,t}^i$ is bounded from below by $U_c^i\left(\widetilde{c}^i(\mu)\right)$, we can apply the martingale convergence theorem, which implies that $U_{c,t}^i$ converges almost surely to a random variable. Suppose, by contradiction, that $U_{c,t}^i$ converged to a value strictly larger than $U_c^i\left(\widetilde{c}^i(\mu)\right)$, which would imply that consumption levels would converge to values $\widehat{c}^i < \widetilde{c}^i(\mu)$, so that the consumption-leisure choice would be interior for at least one of the two spouses when employed. In that case labor income would converge to $\iota \equiv w^f(1 - \widehat{l}^f)s^f + w^m(1 - \widehat{l}^m)s^m$, where $\widehat{l}^f$ and/or $\widehat{l}^m$ are strictly smaller than 1 and solve (1.2.13) and (1.2.14). ι is a non-degenerate random variable with positive variance, which implies that the lower or upper bounds on asset holdings would be violated with positive probability, a contradiction. This follows from the result of Chamberlain and Wilson (2000) that under $\beta(1+r) = 1$ consumption and asset grow with no bound if income is suitably stochastic. Thus, $U_{c,t}^i$ cannot converge to a value strictly larger than $U_c^i\left(\widetilde{c}^i(\mu)\right)$ and it must converge to $U_c^i\left(\widetilde{c}^i(\mu)\right)$. Since U_c^i is invertible, consumption will converge to $\widetilde{c}^i(\mu)$. The budget constraint implies that a_t must converge to $\widetilde{a}(\mu)$.

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Appendix II: The Complete Markets Economy

Let $\theta(\boldsymbol{s})$ denote the number of Arrow securities owned by the collective household. Then the household solves the following problem:

$$
\begin{aligned}
V\big(\boldsymbol{s},\theta(\boldsymbol{s});x,\boldsymbol{z}\big) &= \max_{c^f,c^m,l^f,l^m,\theta'(\boldsymbol{s}')}\Big\{\mu(x,\boldsymbol{z})U^f(c^f,l^f)+[1-\mu(x,\boldsymbol{z})]U^m(c^m,l^m) \\
&\qquad +\beta\sum_{\boldsymbol{s}'}\pi_{\boldsymbol{s}'|\boldsymbol{s}}V\big(\boldsymbol{s}',\theta'(\boldsymbol{s}');x,\boldsymbol{z}\big)\Big\} && (1.6.10)\\
c^f+c^m &+ \sum_{\boldsymbol{s}'}p(\boldsymbol{s},\boldsymbol{s}')\theta'(\boldsymbol{s}') = \sum_{i=f,m}w^i(1-l^i)s^i+\sum_{i=f,m}(1-s^i)b^i+\theta(\boldsymbol{s}) && (1.6.11)\\
c^f,c^m \geq 0, &\qquad 0\leq l^f,l^m\leq 1. && (1.6.12)
\end{aligned}
$$

where $p(\boldsymbol{s},\boldsymbol{s}')$ denotes the price of an Arrow security that is purchased by a household in state s and pays one unit of the consumption good in the subsequent period if state $\boldsymbol{s}'$ is realized. For a household with relative Pareto weight μ in state $\boldsymbol{s}$, solving (1.6.10) yields the following system of optimality conditions:

$$
\begin{aligned}
\mu U_c^f &= (1-\mu)U_c^m && && (1.6.13)\\
\frac{U_l^f}{U_c^f} &\geq w^f s^f && \text{with inequality if } l^f=1 && (1.6.14)\\
\frac{U_l^m}{U_c^m} &\geq w^m s^m && \text{with inequality if } l^m=1 && (1.6.15)\\
U_c^f &= \beta\frac{\pi_{\boldsymbol{s}'|\boldsymbol{s}}}{p(\boldsymbol{s},\boldsymbol{s}')}U_c^{f\prime} && \forall \boldsymbol{s}'\in S\times S. && (1.6.16)
\end{aligned}
$$

Imposing the no-arbitrage condition, $1+r=\frac{\pi_{\boldsymbol{s}'|\boldsymbol{s}}}{p(\boldsymbol{s},\boldsymbol{s}')}$, one can rewrite the Euler equation as,

$$U_c^f=\beta(1+r)U_c^{f\prime} \qquad \forall \boldsymbol{s}'\in S\times S. \qquad (1.6.17)$$

For a steady-state equilibrium to exist we will require $\beta(1+r)=1$, and the previous expression simplifies to

$$U_c^f=U_c^{f\prime} \qquad \forall \boldsymbol{s}'\in S\times S. \qquad (1.6.18)$$

That is, households choose $\theta(\boldsymbol{s}')$ such that the marginal utility of consumption is equalized across different states and different points in time. In the special case when utility is separable between consumption and leisure, consumption *levels* are independent of the individual state and constant over time.

Definition: A stationary recursive competitive equilibrium with complete markets in the economy with collective households is a list of functions $\{V,c^f,c^m,l^f,l^m,\theta,K,L^f,L^m\}$, a measure of households ψ, a set of prices $\{r, \bar{w}^f, \bar{w}^m\}$, taxes $\{\tau^f, \tau^m\}$ and benefits $\{b^f, b^m\}$, and a pricing function $pp(s, s')$ such that:

(1) Given prices, taxes and benefits, V is the solution to (1.6.10) – (1.6.12), and $c^f\big(\boldsymbol{s}, \theta(\boldsymbol{s}); \mu\big)$, $c^m\big(\boldsymbol{s}, \theta(\boldsymbol{s}); \mu\big)$, $l^f\big(\boldsymbol{s}, \theta(\boldsymbol{s}); \mu\big)$, $l^m\big(\boldsymbol{s}, \theta(\boldsymbol{s}); \mu\big)$ and $\theta'\big(\boldsymbol{s}', \boldsymbol{s}, \theta(\boldsymbol{s}); \mu\big)$ are the associated optimal policy functions.

(2) For given prices, K, L^f and L^m satisfy the firm's first-order conditions:

  (i) $r = F_K(K, L) - \delta$

  (ii) $w^f = (1-\lambda)F_L(K, L)$

  (iii) $w^m = \lambda F_L(K, L)$.

(3) Aggregate factor inputs are generated by the policy functions of the agents:

  (i) $K = \int_M \int_X p(\boldsymbol{s}, \boldsymbol{s}')\theta'\big(\boldsymbol{s}', \boldsymbol{s}, \theta(\boldsymbol{s}); \mu\big) d\psi dG$,

  (ii) $L^f = \int_M \int_X \boldsymbol{s}\big[1 - l^f\big(\boldsymbol{s}, \theta(\boldsymbol{s}); \mu\big)\big] d\psi dG$,

  (iii) $L^m = \int_M \int_X \boldsymbol{s}\big[1 - l^m\big(\boldsymbol{s}, \theta(\boldsymbol{s}); \mu\big)\big] d\psi dG$.

(3) The pricing function $p(s, s')$ satisfies a no-arbitrage condition: $1 + r = \frac{\pi_{s'|s}}{p(s,s')}$.

(4) The steady-state condition $\beta(1 + r) = 1$ holds.

(5) The government budget is balanced: $q_0^f b^f + q_0^m b^m = \tau^f \bar{w}^f L^f + \tau^m \bar{w}^m L^m$.

Appendix III: Frisch Elasticities of Labor Supply

Since the Pareto weight, $\mu(x, \boldsymbol{z})$, where

$$x \equiv \frac{q_1^f(1-\tau^f)\bar{w}^f + q_0^f b^f}{q_1^m(1-\tau^m)\bar{w}^m + q_0^m b^m}, \tag{1.6.19}$$

is a function of female and male wages, Frisch elasticities of labor supply depend both on the Pareto weight and its derivative with respect to wages. In this Appendix we derive the Frisch elasticity of labor supply for females and males. For convenience, we write again the first-order conditions with respect to leisure at an interior solution. If we use Λ to denote the marginal utility of wealth, these first-order conditions are

$$\mu(x, \boldsymbol{z})U_l^f = \Lambda w^f \tag{1.6.20}$$

$$(1 - \mu(x, \boldsymbol{z}))U_l^m = \Lambda w^m. \tag{1.6.21}$$

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The Frisch elasticity of labor supply, say η^i, of an agent of gender $i = f, m$ captures how her/his labor supply responds to an intertemporal reallocation of wages that leaves the marginal utility of wealth unchanged, i.e.

$$\eta^i \equiv \frac{d(1-l^i)}{dw^i} \frac{w^i}{1-l^i}\bigg|_{\Lambda}. \tag{1.6.22}$$

For females, the Frisch elasticity can be readily obtained after differentiating equation (1.6.20) with respect to w^f, which yields

$$\mu_1 \frac{q_1^f}{q_1^m w^m + q_0^m b^m} U_l^f + \mu U_{ll}^f \frac{dl^f}{dw^f} = \Lambda, \tag{1.6.23}$$

where μ_1 denotes the derivative of μ with respect to it first argument, x. After plugging the value for Λ and multiplying through by $w^f/(1-l^f)$ one obtains

$$\eta^f = -\frac{U_l^f}{(1-l^f)U_{ll}^f}\left(1 - \frac{\mu_1}{\mu}\frac{q_1^f w^f}{q_1^m w^m + q_0^m b^m}\right). \tag{1.6.24}$$

Equivalently, the Frisch elasticity for males can be derived by differentiating (1.6.21) with respect to w^m,

$$\mu_1 \frac{x q_1^m}{q_1^m w^m + q_0^m b^m} U_l^m + (1-\mu) U_{ll}^m \frac{dl^m}{dw^m} = \Lambda. \tag{1.6.25}$$

After rearranging terms, plugging in the value of Λ from the first-order condition and multiplying through by $w^m/(1-l^m)$ gives

$$\eta^m = -\frac{U_l^m}{(1-l^m)U_{ll}^m}\left(1 - \frac{\mu_1}{1-\mu}\frac{x q_1^m w^m}{q_1^m w^m + q_0^m b^m}\right). \tag{1.6.26}$$

Appendix IV: Household Risk Aversion with Risk Sharing

In this appendix we derive the coefficient of risk aversion of the two-person collective household as a function of individual preferences for risk and the relative Pareto weight. We also show that the derivative of the risk-sharing rule for a household member of gender $i = f, m$, is given by the product of the household's coefficient of risk aversion and the individual's coefficient of risk tolerance. The coefficient of absolute risk aversion of a bachelor household with instantaneous utility function $U^i(c, l)$ is defined as

$$\rho^i = -\frac{U_{cc}^i}{U_c^i}, \text{ for } i = f, m.$$

For the utility function assumed in (3.5), this coefficient is σ^i/c.

When two individuals with different attitudes towards risk form a household and share risks, the household's coefficient of risk aversion is obviously different from individual ones. Collective household's risk preferences will depend on individual preferences and Pareto weights.

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Collective Household's Risk Aversion

Let us denote the utility function of the two-person, collective household over total household consumption, y, and individual leisures, l^f and l^m, by $u(y, l^f, l^m; \mu)$. This utility function is defined as,

$$u^\mu(y, l^f, l^m) = \max_{c^f, c^m} \{\mu U^f(c^f, l^f) + (1-\mu) U^m(c^m, l^m)\} \tag{1.6.27}$$

$$s.t. = c^f + c^m = y. \tag{1.6.28}$$

With this utility function we can write the maximization problem solved by the collective household as,

$$\tilde{V}(\boldsymbol{s}, a; \mu) = \max_{l^f, l^m, a', \tilde{c}} \{u(\tilde{c}, l^f, l^m; \mu) + \beta \sum_{\boldsymbol{s'}} \pi_{\boldsymbol{s'}|\boldsymbol{s}} \tilde{V}(\boldsymbol{s'}, a'; \mu)\} \tag{1.6.29}$$

$$s.t. \qquad \tilde{c} + a' = \sum_{i=f,m} w^i(1-l^i)s^i + \sum_{i=f,m} (1-s^i)b^i + (1+r)a. \tag{1.6.30}$$

The coefficient of absolute risk aversion of a collective household with Pareto weight μ can then be defined as,

$$\rho_\mu = -\frac{u_{yy}}{u_y}.$$

To derive this coefficient of risk aversion let us consider the first-order condition to the static maximization problem embedded into the household problem,

$$\mu \varphi_c^f (c^f)^{-\sigma^f} = (1-\mu) \varphi_c^m (c^m)^{-\sigma^m}. \tag{1.6.31}$$

Taking logarithms on both sides of equation (6.32) and differentiating with respect to y yields,

$$\sigma^f \frac{dc^f}{dy} \frac{1}{c^f} = \sigma^m \frac{dc^m}{dy} \frac{1}{c^m}. \tag{1.6.32}$$

Using that $\frac{dc^f}{dy} + \frac{dc^m}{dy} = 1$, we can solve for for dc^f/dy as,

$$\frac{dc^f}{dy} = \left(1 + \frac{\sigma^f}{\sigma^m} \frac{c^m}{c^f}\right)^{-1}. \tag{1.6.33}$$

Now, if we take the derivative of u^μ with respect to y and use the first-order condition (6.32), it gives,

$$u_y = \mu \varphi_c^f (c^f)^{-\sigma^f}. \tag{1.6.34}$$

Differentiating (6.35) with respect to y again yields,

$$u_{yy} = -\sigma^f \mu \varphi_c^f (c^f)^{-\sigma^f - 1} \frac{dc^f}{dy}. \tag{1.6.35}$$

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Then, the coefficient of absolute risk aversion of a household with Pareto weight μ is,

$$\rho_\mu = \frac{\sigma^f \sigma^m}{\sigma^m c^f + \sigma^f c^m}, \tag{1.6.36}$$

and the coefficient of relative risk aversion is $\frac{\sigma^f \sigma^m (c^f + c^m)}{\sigma^m c^f + \sigma^f c^m}$.

Now, it is straightforward to show that the derivatives of the sharing rules, $\frac{dc^f}{dy}$ and $\frac{dc^m}{dy}$, are given by the household's coefficient of absolute risk aversion, ρ_μ, times the coefficient of absolute risk tolerance of each individual in the household. Simple algebra in equation (6.32) leads to

$$\frac{dc^f}{dy} = \left(\frac{\sigma^f \sigma^m}{\sigma^m c^f + \sigma^f c^m} \right) \frac{c^f}{\sigma^f}, \tag{1.6.37}$$

where the expression within brackets on the right-hand side is the household's coefficient of absolute risk aversion and the second term, c^f / σ^f, is the individual's coefficient of absolute risk tolerance. The same result can be shown for $\frac{dc^m}{dy}$.

1.7 Figures

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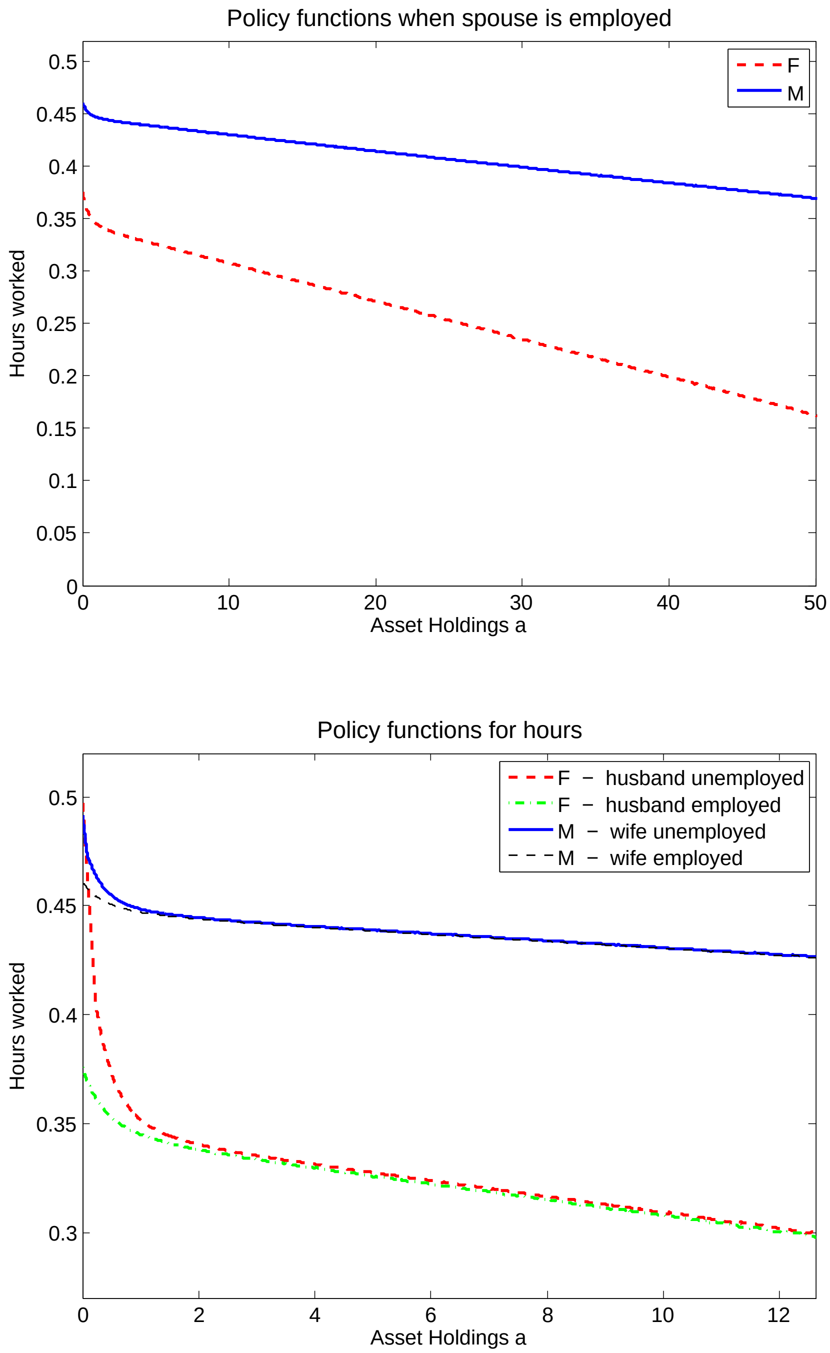

Figure 1.1: Policy functions for labor supply in the collective model

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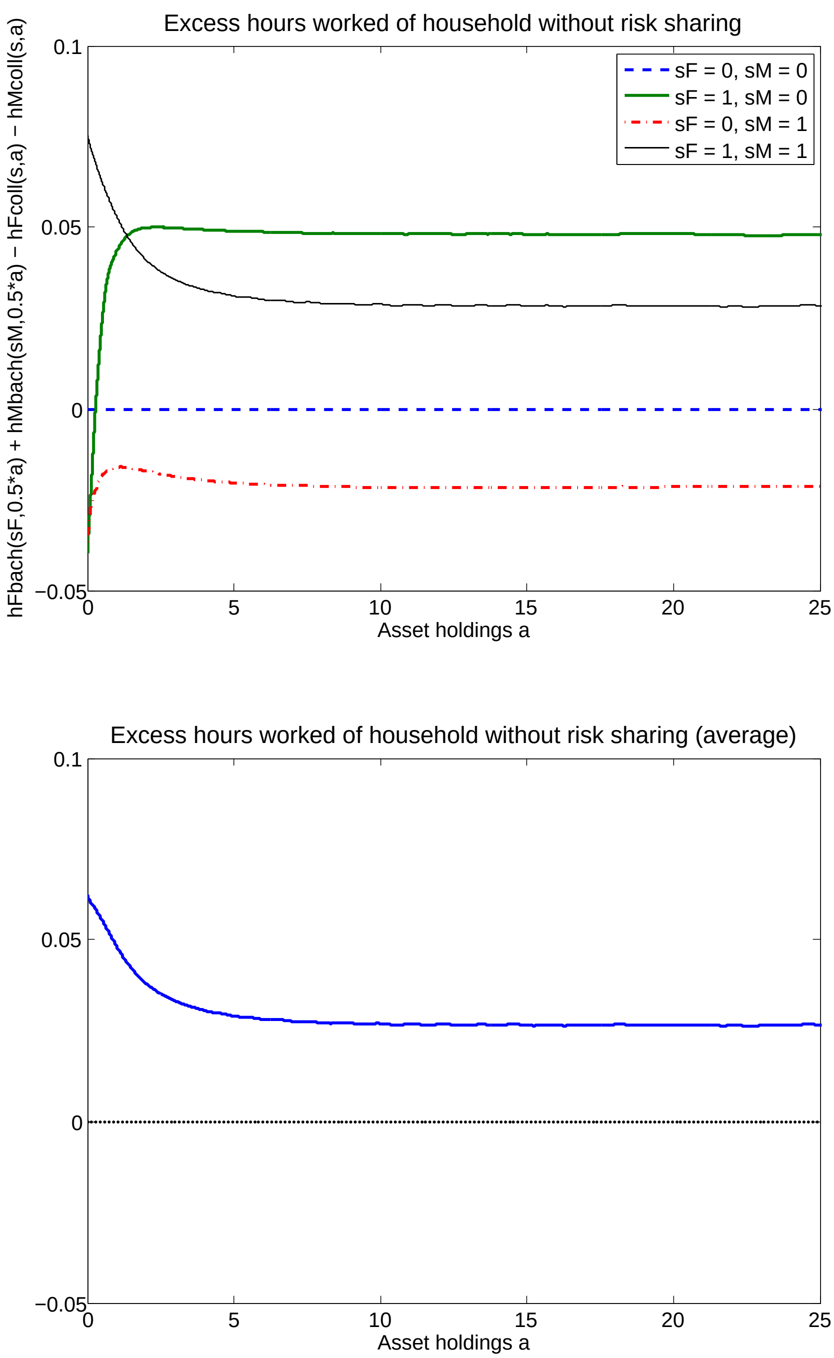

Figure 1.2: Excess hours worked of household without risk sharing

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Chapter 2

A Theory of Inequality between Single and Married Households

Keywords: Inequality; Wealth Distribution; Collective Model; Incomplete Markets.

JEL Classification Numbers: D13; D31; D91; E21.

2.1 Introduction

Marriage is one of the most important determinants of economic prosperity. Yet somewhat surprisingly, most existing theories of inequality abstract from the role of the family: the standard framework for studying inequality treats all households as being comprised of a single decision-maker, without making the role of the marital status explicit. The main purpose of this paper is to fill this void and present a theory that can account for the observed inequality between single and married households.

The cross-sectional distributions of earnings, income and wealth in the United States display a large degree of concentration.[1] When disaggregated into married and single households, economic prosperity remains very unequally distributed within both subgroups, and there is a striking divergence in per-capita means: on average, married people have 49.4 percent higher labor earnings, they earn 26.8 percent more income, and they are 33.5 percent richer than singles. These disparities are not driven by extremely rich households since the corresponding ratios of medians look very similar. In light of the empirical relevance of the family – in the

[1] See Díaz-Giménez/Glover/Ríos-Rull (2007), Heathcote/Perri/Violante (2010) and Hintermaier/Königer (2010).

year 2009, half of the adult population in the United States was married – reconciling the strong association between marital status and economic outcomes is a challenge that models of inequality must face.

The contribution of this paper is twofold. First, I show that a standard incomplete-markets life-cycle model augmented by two different household types, single and married, fails to account for the positive relationship between marriage and wealth. The reason is that the risk-sharing component of household saving attenuates the precautionary motive for families with multiple earners and, hence, counterfactually predicts lower per-capita savings. Second, I present a theory that can, to a large extent, quantitatively account for the distributions of earnings, income and wealth across single and married households. One of the novel features I propose relates to the explicit distinction between intentional and accidental bequests: if intergenerational ties are tighter in families with descendants, they have an additional incentive to transmit their estates to the next generation. Furthermore, I capture the bonus incorporated in the U.S. tax system which effectively favors married couple, and I assess the role of positive assortative mating in conjunction with a higher propensity to marry for college-educated people.

The model economy I present in this paper is a version of the neoclassical growth model with uninsurable, idiosyncratic risk (see Aiyagari (1994)). Following recent studies in the literature, I mix some desirable features of both life-cycle and dynasty models by assuming stochastic transitions from working age to retirement and eventually death. Throughout their working age, individuals receive idiosyncratic labor efficiency shocks. They use buffer-stock savings in a riskless asset, subject to a borrowing constraint, to smooth consumption over time, and they save for retirement. Since there are no aggregate shocks in the economy, the model yields a stationary distribution over asset holdings and employment shocks that can be compared to the data. My further modeling choices are motivated by the main focus of this paper. I assume that there are equally many female and male individuals who are randomly selected into households of different sizes when entering the economy. Some households consist of one person ("single"), others consist of two persons ("married'). Two-person households, formed by a female and a male, pool their income and make collective decisions on individual consumptions, labor supplies and joint savings. Individual weights in the household's utility function are determined upon matching and remain unchanged thereafter.

This basic framework is extended in three major dimensions. First, I introduce a permanent component into the specification of the idiosyncratic labor efficiency process in order to capture the college premium in wages. Modeling the interplay between assortative match-

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ing and a higher propensity to marry for college-educated people is a necessary ingredient to partially account for the income and wealth disparity between single and married people. Second, I acknowledge that the U.S. tax code encourages married couples to file their taxes jointly. Joint filing will often result in a more favorable tax bracket and, thus, raise permanent disposable income. Since precautionary saving is typically associated with a target wealth-to-permanent-income ratio, married couples are led to save more. My findings indicate, in fact, that modeling the tax bonus significantly contributes to generating a positive wealth gap. Third, I propose a novel way of linking the transmission of wealth across generations, and I distinguish explicitly between intentional and accidental bequests by relating the bequest motive to the presence of descendants. Families who are altruistic towards their offspring will decumulate assets at a slower rate at the end of their lives, which may help to explain why married people save more.

A calibrated version of my benchmark model does a good job of accounting for the empirical distributions of earnings, income and wealth across single and married households in the United States. The model successfully reproduces significantly greater per-capita earnings and wealth for married individuals; by contrast, a standard model that lacks the three additional channels laid out above fails to generate a large disparity for income, and it counterfactually predicts that singles hold more wealth. The latter result is due to the fact that intrahousehold risk sharing strongly attenuates the precautionary saving motive. Then, in a series of counterfactual experiments, I deactivate the three additional channels one by one in order to quantify their relative importance for my results. My findings indicate that properly accounting for the assortative matching component of marriage formation, the tax bonus for married households and the distinction between accidental and intentional bequests all contribute significantly to explaining the per-capita gap in wealth. Finally, in order to assess the actual implications of joint tax filing, I use my model economy to conduct a hypothetical policy reform that abolishes this possibility. My results suggest that moving to separate tax filing would lead to large aggregate welfare gains, but, at the same time, widen the per-capita wealth gap even further, because married couples would be forced to save more for precautionary reasons.

This paper mostly relates to two strands of literature. First, it builds upon earlier work that studies cross-sectional income and wealth inequality in general equilibrium frameworks with heterogeneous agents, e.g. Aiyagari (1994), Huggett (1996), Krusell and Smith (1998), Castañeda et al. (2003) and De Nardi (2004). In particular the last two examples share large commonalities with the model presented in this paper since they also study environments with life-cycle and dynastic elements. All of these studies, however, abstract from modeling the marital status of a household. A second body of literature makes this distinction more

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explicit by considering single and married households separately; examples include Aiyagari et al. (2000), Greenwood et al. (2003), Cubeddu and Ríos-Rull (2003) and Hong and Ríos-Rull (2003).

To the best of my best knowledge, there is no theoretical work on per-capita differences between single and married households and cross-sectional income and wealth inequality in a joint context. The study most closely related to this one is a working paper by Guner and Knowles (2004) who also investigate the link between marriage and wealth in a dynamic OLG setting. In their model, single agents and married couples make decisions on consumption, hours worked and savings, and they decide whom to marry and when to divorce, in anticipation of future outcomes. The authors show that their model can generate a significant positive wealth gap. The main difference to my framework is that Guner and Knowles (2004) model consumption within married households as a public good and calibrate it using estimates for adult equivalence scales, which may be a driving force for their results. Furthermore, since their model only consists of three periods, it neglects the strong family insurance effect for precautionary saving and probably performs poorly when tested along the cross-sectional dimension.

The divergence in effective taxation between single and married households and the role of joint tax filing has been the subject of a recent study by Guner, Kaygusuz and Ventura (2008). These authors construct a life-cycle economy populated by single and married workers who differ according to their labor efficiency and age. At the heart of their analysis lies an exogenous utility cost of participating in the labor market. This assumption allows them to focus on the extensive margin of married female labor supply. The authors use their model to evaluate various tax reforms, *inter alia* the abolition of joint tax filing. Their results associate substantial welfare gains with such a reform and, thus, share a commonality with my own findings. In contrast to the findings presented in this paper, however, their model predicts output gains. This divergence could potentially be explained by a different assumption on how to redistribute additional tax revenues: they choose to adjust proportional tax rate, whereas I use lump-sum transfers.

The role of a bequest motive to generate a lifetime saving profile consistent with the data has been recently put under examination. De Nardi (2004) shows that intentional bequests can explain the emergence of very large estates and, therefore, help to generate a high degree of concentration at the upper tail of the wealth distribution. Fuster et al. (2008) study the significance of intergenerational links for the impact of various tax reform proposals. They confront two polar frameworks: a pure life-cycle model, on the one hand, and a dynastic

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model with altruistic links, on the other hand. They find that tax reforms can have very different implications depending on whether individuals derive utility from bequeathing to their descendants or not. Laitner (2001) introduces the existence of intentional and unintentional bequests in a common framework. In his model, a constant fraction λ of households care about their descendants, the remaining population only cares about their own lives. In comparison to his approach, a novel element in my model is to relate the existence of a bequest motive explicitly to the presence of a descendant.

The remainder of the paper is organized as follows. Section 2 provides a documentation of the most relevant empirical facts motivating this study. In section 3, I present my benchmark model economy and define a stationary equilibrium. The calibration strategy is described in Section 4, and Section 5 contains my results. Concluding remarks are offered in Section 6.

2.2 The Data

To motivate this study, this section documents a number of stylized facts for the distributions of earnings, income and wealth in the United States. Most of the subsequent data analysis is based on the 2007 wave of the Survey of Consumer Finances (SCF).[2] One advantage of the SCF is that it provides information on all three variables of interest for this study, whereas e.g. the Current Population Survey (CPS) does not collect any data on household wealth. A second advantage is that the Survey of Consumer Finances explicitly oversamples wealthy households and employs appropriate weighting schemes to adjust for higher non-response rates among rich households. Therefore, the SCF provides a more accurate description of the upper tails of the various distributions, as distinguished from other U.S. household surveys such as the CPS or the PSID.

For the purpose of this study, I restrict the sample to comprise only households where the head is at least 25 years old. I make an additional adjustment by excluding the wealth-richest 1 % households for the following reason. In a previous study, Castañeda, Díaz-Giménez and Ríos-Rull (2003) find that matching the concentration at the very top of the wealth distribution requires a small-probability state of extremely high hourly wages. For instance, in their benchmark economy agents in the highest efficiency state are more than 100 times more productive than those in the second-highest state, and they are more than 1,000 times more productive than agents in the lowest state. In the model presented in the next section agents draw their labor efficiency based on a stochastic earnings process that has been estimated

[2] A detailed description of the data and variable definitions are provided in Appendix I.

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Table 1. Summary statistics

	Mean ($)	Median ($)	Gini	Bottom 40%
All Households				
Labor earnings	57,076	37,364	0.59	4.72
Total income	73,868	48,745	0.50	11.71
Wealth	398,872	136,750	0.72	1.81
Married Households				
Labor earnings	78,819	56,560	0.53	8.79
Total income	99,768	68,489	0.48	13.51
Wealth	551,571	191,800	0.72	2.82
Single Households				
Labor earnings	26,416	15,426	0.63	0.54
Total income	39,348	29,617	0.44	14.14
Wealth	206,555	63,846	0.71	0.66

Source: 2007 wave of the Survey of Consumer Finances (SCF).

from PSID data. Since the very rich households are neither present in the PSID nor in my model, I choose to abstract from them.[3]

The upper panel in Table 1 summarizes a selection of distributional statistics for labor earnings, total income and wealth across households in the U.S. economy. As is well known, all three variables are very unequally distributed, with wealth being by far the most concentrated one among them. For instance, households belonging to the bottom 40 percent of the respective distribution earn 11.7 percent of income and they hold only 1.8 percent of total wealth. The Gini coefficient – a more sensitive concentration measure for the upper tail of the distribution – exceeds 0.5 for all variables of interest and is particularly high for wealth (0.72). These facts indicate that the cross-sectional distributions of earnings, income and wealth are highly skewed to the right, with fat lower tails and a very thin upper tail.

The middle and lower panels in Table 1 display the same set of statistics when the sample is partitioned into married and single households. As can be seen, earnings, income and wealth remain very unequally distributed across the two subsamples. A notable difference is the slightly fatter lower tail for the wealth distribution of single households - the poorest 40 percent hold almost no assets. More strikingly, married households earn significantly more income and hold substantially more assets than single households, even when dividing by the

[3]Recent studies by Heathcote, Storesletten and Violante (2010) and Hintermaier and Königer (2011) pursue a similar strategy.

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number of household members (cf. Table 1, first two columns). To make this point more explicit, I define

$$\Delta(x) \equiv 100 \cdot (0.5\, x^{\mathcal{M}}/x^{\mathcal{S}}), \tag{2.2.1}$$

where I compute the ratio between married and single households, $x^{\mathcal{M}}/x^{\mathcal{S}}$, and then divide it by 2 to obtain a measure for the discrepancy in per-capita values for variable x.

Table 2 reports the resulting values for this measure. As can be seen in the table, married individuals earn on average 49.4 percent more labor income, their total income is 26.1 percent higher, and they hold 33.5 percent more wealth than single households. A possible objection is to argue that many people get married later than at the age of 25, which would imply that they enter the sample of married households at a later point of their increasing life-cycle profile of earnings and wealth. To check for this possibility, I restrict the sample to households where the head is at least 30 years old, an age by which most of the first marriages have been formed.[4] If the previous point is valid, one would expect that per-capita differences diminish, but instead they rise even further. This suggests that the gap at young age is comparatively small and then opens up over the life cycle.

To further investigate this point, I divide the sample into working-age and retirement-age subgroups (cf. Table 2). Labor earnings for working-age married individuals are on average 25.6 percent higher than for working-age singles. The corresponding statistic for retired individuals is with +140 percent much higher, but this result is mainly driven by the fact that there are more married people who work at old age. As for per-capita income and per-capita wealth, the picture is similar: married individuals earn on average 17.5 percent more income and they hold 38.4 percent more assets. During retirement age the discrepancy jumps up to +43.7 percent (total income) and +50.8 percent (wealth) respectively.

It must be noted that the sample of single households comprises widowed individuals, and that the share of widows is substantially larger for the retirement subsample. In order to evaluate the impact of this fact, the last line of Table 2 reports the per-capita wealth gap for people at retirement age if widowed singles are excluded. The discrepancy rises even further to +69.2 percent. This suggests that widowed retired individuals are substantially better off than other singles, which is consistent with the previous findings under the assumption that the death of one spouse does not intrinsically elevate the survivor's economic well-being to a large extent.[5]

[4]The U.S. Census Bureau reports that the median age at first marriage for women and men in the year 2009 was 26.5 and 28.4 respectively.

[5]In the model presented in the next section I will abstract from widows by assuming that married couples decease jointly.

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Table 2. Per-capita differences between married and single households

	Popul share (%)	Δ^{Mean}	Δ^{Median}
Labor earnings			
All households	100.0	+ 49.4	+ 83.3
Age 30+	92.1	+ 55.3	+ 97.8
Working age (25 – 59)	69.9	+ 25.6	+ 13.8
Retirement age (60+)	30.1	+ 140.0	–
All households (CPS)	100.0	+ 27.6	+ 52.5
Total income			
All households	100.0	+ 26.8	+ 15.6
Age 30+	92.1	+ 30.1	+ 20.4
Working age (25 – 59)	69.9	+ 17.5	+ 10.8
Retirement age (60+)	30.1	+ 43.7	+ 9.5
All households (CPS)	100.0	+ 12.8	+ 24.5
Wealth			
All households	100.0	+ 33.5	+ 50.2
Age 30+	92.1	+ 34.3	+ 45.6
Working age (25 – 59)	69.9	+ 38.4	+ 116.8
Retirement age (60+)	30.1	+ 50.8	+ 7.6
Retirement - no widows	21.4	+ 69.2	+ 30.3

Sources: 2007 wave of the Survey of Consumer Finances (SCF) and March 2010 wave of the Current Population Survey (CPS).

Are these results driven by extreme observation, e.g. by very rich households? To answer this question, Table 2 also documents per-capita differences in median values (cf. last column). The disparity of per-capita wealth between the median married household and the median single household is with +50.2 percent even more pronounced than the corresponding value for per-capita means (+33.5 percent), whereas the opposite is true for total income (+15.6 percent compared to +26.8 percent). The per-capita gap in median labor earnings for households of all age groups rises to +83.3 percent. A more meaningful comparison between working-age married and single households yields a gap of +13.8 percent. As a final robustness exercise, I investigate whether my previous findings are in some way specific to the relatively small SCF sample by performing a similar analysis for the Current Population Survey (CPS) with its much larger sample size. As can be seen in Table 2, per-capita gaps for average earnings (+27.6 percent) and income (+12.8 percent) remain notably high. They are slightly smaller than in the SCF, which is perhaps not surprising as income-rich households are underrepresented in

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the CPS.[6]

To summarize, the preceding analysis has uncovered a set of empirical facts pertaining to cross-sectional inequality between single and married households in the United States. The next section turns to presenting a theoretical model that aims at accounting for these facts.

2.3 The Model

2.3.1 Preliminaries

Demographics. Consider an economy that is populated by a continuum of measure one of households. In each period $t = 0, 1, 2, \ldots,$ a cohort of new individuals enters the economy. Half of them are born are females, the other half are born as males. The life cycle of an individual consists of three phases: household formation, working age and retirement. The first phase takes place before an agent enters the economy ("time 0") and determines whether individuals will commence their working life as singles or couples. Once households are formed, they are either comprised of one single adult or two married adults, one female and one male. Households can be either in the working-age or the retirement stage. At the end of each period, working-age households face a constant exogenous probability of becoming retired, and retired households face a constant exogenous probability of dying. When a retired household dies, its members are replaced by an equal number of newborn agents. The deceased household's financial wealth is liquidated and transmitted to the next generation.[7] Inheritance takes place before individuals start working, but after households have been formed. In addition, married couples face an exogenous probability of separation throughout the working-age and retirement stages ("divorce"). Divorced agents form single households for the rest of their lives.

Preferences. All agents enjoy the consumption of an aggregate good and of leisure time. Preferences for agents of gender $g \in \{f, m\}$ can be described by a per-period utility function $U^g(c_t, l_t)$, where c_t and l_t denote consumption and leisure in period t respectively, and a common discount factor $\beta \in (0, 1)$. I will assume that U^g is strictly increasing and strictly concave in each of its arguments, twice continuously differentiable and satisfies the Inada conditions. In addition, agents derive utility from bequeathing their estate to their descendants.

Employment opportunities. In each period, agents are endowed with one unit of disposable time and an individual level of labor productivity e that depends on their history of

[6] There is no comparative value for wealth since the CPS does not collect any data on household net worth.
[7] The transmission of wealth is detailed below.

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idiosyncratic shocks. Retired agents are not productive at all, i.e. $e = 0$. In the working-age phase, the labor productivity of individual i at time t is given by

$$e_t^i = \exp\left(\xi^i + z_t^i\right), \tag{2.3.1}$$

where ξ^i is a permanent component that is determined when an agent is born and may be interpreted as an ability shock. I assume that ξ^i is drawn from a finite set Ξ that contains zero as an element. The time-varying part of labor productivity, z_t^i, evolves according to an AR(1) process,

$$z_t^i = \rho z_{t-1}^i + \epsilon_t^i, \qquad \text{with } \epsilon_t^i \overset{\text{i.i.d.}}{\sim} N(0, \sigma_\epsilon^2), \tag{2.3.2}$$

where ρ measures the longevity of temporary productivity shocks. To model transitions to retirement, at the end of each period, there is a probability ϕ^R that labor productivity is set to zero permanently, i.e. $e_{\widetilde{t}}^i = 0,\ \forall \widetilde{t} = t+1,\ t+2, \ldots$. Agent i's labor productivity in period t can then be summarized as $s_t^i \equiv (\xi^i, e_t^i)$, where $s_t^i \in S \equiv \Xi \times \mathbb{R}$ implicitly describes whether an agent is in working age, $e > 0$, or retired, $e = 0$.

Household formation. Before a new cohort of agents enters the working-age stage, it is determined whether they will start their economic lives in a one-person ("single") or two-person ("married") household. I assume that there is a marriage market that randomly matches two individuals i and j of opposite gender according to an exogenous probability $q^g_{\xi^i,\xi^j}$ that potentially depends on their relative abilities. The latter assumption allows me to model the positive assortative matching component of couple formation, which implies the significant correlation between permanent wages that is observed in the data.[8] Once two individuals are matched, they enter into a cooperative bargaining process that prescribes efficiency for the resulting allocation ("collective assumption"). If they reach an agreement, they can fully commit to this outcome and form a two-person household until their marriage is dissolved exogenously or they die together. Individuals who are left unmatched remain singles and form one-person households. After individuals have been selected into households, it is furthermore determined whether the household has descendants ($d = 1$) or not ($d = 0$). The presence of descendants has an impact on the bequest motive and occurs according to an exogenous probability that depends on the marital status.

Intergenerational transmission. Successive generations of individuals are linked through the transmission of assets in the following stylized way. I assume that every deceased married couple leaves their estate to *two* new entrants in equal shares, i.e. each of the two entrants

[8] See Hyslop (2001).

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inherits half of the assets. Moreover, I assume that for every deceased single agent there is another single agent of opposite gender who deceases at the end of the same period; upon death their estates are pooled and left to two new entrants in equal shares. From the perspective of newborn individuals, initial asset holdings are determined when they enter the working age, i.e. after the household formation stage. Each new entrant inherits either half of the estate of a randomly selected deceased married couple, or half of the sum of assets of two randomly selected deceased single individuals of opposite gender.[9]

Firms. Production of the aggregate good is conducted by a continuum of competitive firms. The representative firm operates a technology that can be represented by the Cobb-Douglas production function $F(K,L) = K^{\alpha}L^{1-\alpha}$, where K is the aggregate stock of capital, L is aggregate labor and $0 < \alpha < 1$ is the capital's share of income. Female and male labor are assumed to be perfect substitutes, $L \equiv \lambda L^m + (1-\lambda)L^f$, where λ is a parameter that pins down relative productivities and can thus be used to model the gender gap in wages. The firm's maximization problem is static: given a rental price of capital r and gross wages for females and males w^f and w^m, respectively, first-order conditions are:

$$F_K(K,L) = r + \delta \tag{2.3.3}$$

$$\lambda F_L(K,L) = w^m \tag{2.3.4}$$

$$(1-\lambda)F_L(K,L) = w^f, \tag{2.3.5}$$

where $\delta > 0$ denotes the depreciation rate of capital.

Government. The government levies taxes on households' income, pays out fixed benefits to retired individuals and consumes a public good G. Income taxation for single and married households can be characterized by two functions, $\tau^{\mathcal{S}}(y)$ and $\tau^{\mathcal{M}}(y)$, where total household income y is composed of labor income, capital income and retirement benefits. Benefits are allowed to depend on the gender and ability mix of all household members. The government cannot issue any debt and is thus required to balance its budget on a period-by-period basis.

Market structure. A crucial assumption for the model at hand is that there are no markets for state-contingent contracts in the economy; hence, workers cannot insure perfectly against idiosyncratic labor market uncertainty. Also, there is no annuity market to insure individual

[9] Two clarifying remarks are in order. First, an underlying assumption is that there is a "veil of ignorance" between deceased agents and newborns, in the sense that neither side knows the other's identity until the transmission of assets takes place. Second, a constant population size requires that each deceased individual has on average one descendant. For simplicity, I assume that pairs of agents with $d = 1$ bequeath only to two descendant, and that their other descendants inherit from pairs of agents with $d = 0$. Equivalently, one could assume that each individual has descendants and those with $d = 1$ have a bequest motive.

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mortality risk. The only asset in the economy is physical capital, which pays out the risk-free interest rate r. Moreover, I assume that individuals in this economy are not allowed to borrow, which imposes a zero lower bound on their asset holdings. The latter assumption also implies that agents cannot die in debt.

2.3.2 The Problem of the Household

Single household. For a single agent of gender g the relevant state variables are current wealth a, a vector describing the agent's labor efficiency $s = (\xi, e)$, and whether there are descendants, $d \in \mathcal{D} = \{0, 1\}$.[10] The problem of a single household can be formulated recursively as

$$\begin{aligned} \mathcal{V}^g(a, s, d) \quad &= \quad \max_{c,l,a'} \left\{ U^g(c, l) + [1 - \phi(s)]\, \beta\, E\left[\, \mathcal{V}^g(a', s', d) \mid s \,\right] + \phi(s)\, \beta\, \mathcal{Z}^g(a', d) \right\} \quad (2.3.6) \\ \text{s.t.} \quad & \qquad c + a' = y - \tau^{\mathcal{S}}(y) + a \\ & \qquad y = b^g(s) + (1 - l)\, e\, w^g + ra \\ & \qquad c \geq 0, \quad 0 \leq l \leq 1, \quad a' \in \mathcal{A}, \quad \text{and (2.3.1), (2.3.2),} \end{aligned}$$

where $\mathcal{A} = \left[0, \overline{A}\right]$, and $\overline{A}$ is an upper bound for asset holdings that is sufficiently large such that it never binds. Recall that when a household retires, its labor efficiency is permanently set to zero, $e = 0$. The function $\phi(s)$ describes the probability of dying at the end of the period and takes on a positive value only when a household is already retired. That is,

$$\phi(s) = \phi(\xi, e) = \begin{cases} \phi^D & \text{, if } e = 0, \\ 0 & \text{, if } e > 0. \end{cases}$$

Similarly, retirement benefits $b^g(s)$ are only paid out to retired households. The value of bequeathing remaining estates to descendants, $\mathcal{Z}^g(a', d)$, depends positively on a' and will be described in more detail later.[11]

Married household. Consider now the maximization problem faced by a married household. As explained above, it is assumed that at the time of household formation both members can fully commit to all future allocations. Following the literature of collective households (see Chiappori and Donni (2010) for a recent survey), the utility of each individual in the household

[10] For notational convenience, I will suppress the dependence on interest rates and wages. Since this paper focuses on stationary equilibria only, prices will be constant over time.

[11] It would be straightforward to extend the model in order to allow for an intergenerational transmission of earnings ability (see De Nardi (2004)). Since the model is already fairly complex, I abstract from this possibility.

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carries a weight, reflecting the relative power of that individual in the household. Under full commitment, that is, when household members can commit to future intrahousehold allocations, individual weights are set when the household is formed and remain unchanged thereafter. I write the Pareto weight on female's utility as $\mu(z) \in [0,1]$, where z is a measure of the relative earnings ability of both spouses that is determined at the household formation stage, and μ is a differentiable function. The mapping from z to μ will be described in more detail below. Denote by $\boldsymbol{s} = (s^f, s^m)$ the pair of states describing the labor productivity of both members in a married household, where $\boldsymbol{s} \in \boldsymbol{S} \equiv S \times S$. A married household with fixed Pareto weights μ and $(1-\mu)$ solves

$$\begin{aligned} \mathcal{V}(a, \boldsymbol{s}, d; z) \quad &= \max_{c^f, c^m, l^f, l^m, a'} \Big\{ \mu(z)\, U^f(c^f, l^f) \; + \; [1-\mu(z)]\, U^m(c^m, l^m) + \phi(\boldsymbol{s})\, \beta\, \mathcal{Z}\left(a', d\right) \\ &\qquad + \; [1-\phi(\boldsymbol{s})]\, \beta\, E\left[(1-\psi)\, \mathcal{V}\left(a', \boldsymbol{s}', d; z\right) + \psi\, \mathcal{S}\left(a', \boldsymbol{s}', d; z\right) \;\Big|\; s \right] \Big\} \qquad (2.3.7) \\ \text{s.t.} \quad c^f + c^m + a' \quad &= \quad y - \tau^{\mathcal{M}}(y) + a \\ y \quad &= \quad b(\boldsymbol{s}) + \sum\nolimits_g (1-l^g)\, e^g\, w^g + ra \\ \mathcal{S}(a, \boldsymbol{s}, d; z) \quad &= \quad \mu(z)\, \mathcal{V}^f(a/2, s^f, d) + [1-\mu(z)]\; \mathcal{V}^m(a/2, s^m, d) \\ c^f,\; c^m \geq 0, \qquad &0 \leq l^f,\; l^m \leq 1, \qquad a' \in \mathcal{A}, \qquad \text{and (2.3.1), (2.3.2).} \end{aligned}$$

Married households that do not die at the end of the period face a constant probability ψ of divorcing. In case a divorce occurs, the joint continuation value $\mathcal{S}$ can be constructed as the weighted sum of individual continuation values $\mathcal{V}^f$ and $\mathcal{V}^m$, and all assets are split equally between the two household members.

Household formation. Upon entering the marriage market, agents are characterized by their gender g and their idiosyncratic permanent productivity shock ξ^i. It is assumed that an agent of gender g with ability ξ^i is matched stochastically to an agent of opposite gender and ability ξ^j according to an exogenous probability function $q^g_{\xi^i,\xi^j}$. When two agents are matched, they enter into a collective bargaining process that leads to an efficient allocation decision for all future contingencies. Under full commitment individual Pareto weights are determined during household formation and remain unchanged thereafter. I make the assumption that Pareto weights depend on a measure of the relative earnings ability of the two spouses, which I define as $z \equiv \exp(\xi^f)w^f / \exp(\xi^m)w^m$. It must be noted that in my model the Pareto weight function $\mu(z)$ is not obtained as the outcome of an explicit bargaining process between females and males. Instead, I will use estimates of the sharing rule provided by Browning, Bourguignon, Chiappori and Lechene (1994) to parameterize and solve the model. After married households have been formed, they are assigned descendants with probability $\pi^{\mathcal{M}}$.

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Individuals who are left unmatched in the marriage market enter the economy as single-person households, and they are assigned descendants with probability $\pi^{\mathcal{S}}$.

Bequest motive. A retired individual who does not survive into the following period potentially derives utility from leaving his estate ("bequest motive"). A key feature of my model is that the taste to bequeath wealth depends not only on the size of estates left, but also on the presence of descendants. More specifically, I make the following two assumptions: (a) Individuals only have a bequest motive if they have descendants, i.e. $\mathcal{Z}^f(a', 0) = \mathcal{Z}^m(a', 0) = \mathcal{Z}(a', 0) = 0$; (b) Individuals with descendants are fully altruistic towards them, i.e. their bequest function is equal to the expected value function of the inheritor.[12] Since the information set for all agents is restricted to the mere presence of descendants rather than their identity – i.e. whether they are female/male, married/single, college-educated or not etc. – the bequest utility corresponds to the expected utility function for a generic newborn agent, which can be constructed as the weighted average of expected value functions for agents of both genders, education levels and marital statuses. As stated above, I assume that married couples with descendants leave their estate to two entrants in equal shares. Single agents pool their estates with a randomly selected single agent of opposite gender (second "parent") and leave the pooled estate in equal shares to two entrants. Since single agents do not know the quantity of assets contributed by the other parent before dying, they form rational expectations based on the actual distribution of assets.[13]

2.3.3 Stationary Equilibrium

To keep notation as compact as possible, I will define the state space for all types of households as $\boldsymbol{X} \equiv \boldsymbol{S} \times \mathcal{A} \times \mathcal{D}$, where I arbitrarily impose $\boldsymbol{S} = S \times \{0\} \times \{0\}$ if the household is single.[14] The Borel algebra generated by an appropriate family of subsets of $\boldsymbol{X}$ is denoted by $\mathcal{B}$. Let $\nu(B;\mu)$ be a probability measure describing the mass of households with fixed Pareto weight μ in $B \in \boldsymbol{X}$, where $\nu(B;\mu)$ is defined on $\mathcal{B}$, and I impose $\mu = 0$ for single male households and $\mu = 1$ for single female households. The distribution of Pareto weights in the population of households will be represented by $H(\mu)$ and its support by $M \equiv [0,1]$. Moreover, denote by $P(\boldsymbol{s}, a, B; \mu)$ the probability that a household with Pareto weight μ at state $(\boldsymbol{s}, a, d)$ will transit to a state that lies in $B \subset \mathcal{B}$ in the next period. The transition function P can be

[12] The assumption of full altruism has found some support in recent studies, e.g. Castañeda et al. (2003) and Fuster et al. (2008).

[13] See Appendix III for a formal derivation of the bequest function for single and married households.

[14] As a consequence, the state $\boldsymbol{s}$ characterizes (i) the labor efficiency of all household members, (ii) whether the household is in working age or retirement; and (iii) whether the household is single or married.

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constructed as

$$P(a, \boldsymbol{s}, d, B; \mu) = \int_{\boldsymbol{s}' \in B_{\boldsymbol{s}}} \mathcal{I}_{a'(a,\boldsymbol{s},d;\mu) \in B_a} \, \Omega(\boldsymbol{s}, d\boldsymbol{s}'),$$

where $\mathcal{I}$ is an indicator function taking on a value of 1 if its argument is true and 0 otherwise, $\Omega(\boldsymbol{s}, \boldsymbol{s}' \in B_{\boldsymbol{s}})$ is the probability that the exogenous state next period belongs to $B_s \subseteq \boldsymbol{S}$, and $B_{\boldsymbol{S}}$ and B_a are the projections of $\mathcal{B}$ on $\boldsymbol{S}$ and $\mathcal{A}$ respectively.

Definition: A stationary recursive competitive equilibrium with incomplete markets in this economy is a list of functions $\{\mathcal{V}^f, \mathcal{V}^m, \mathcal{V}, c^f, c^m, l^f, l^m, a', K, L^f, L^m\}$, a measure of households ν, a set of prices $\{r, w^f, w^m\}$ and a government policy $\{\tau, b, G\}$ such that:

1) For given prices, taxes and benefits, $\mathcal{V}^f$, $\mathcal{V}^m$ and $\mathcal{V}$ solve (2.3.6) – (2.3.7), and $c^f(a, \boldsymbol{s}, d; \mu)$, $c^m(a, \boldsymbol{s}, d; \mu)$, $l^f(a, \boldsymbol{s}, d; \mu)$, $l^m(a, \boldsymbol{s}, d; \mu)$ and $a'(a, \boldsymbol{s}, d; \mu)$ are the associated policy functions.

2) For given prices, K, L^f and L^m satisfy the firm's first-order conditions (1.2.2) – (1.2.4).

3) Aggregate factor inputs are generated by the policy functions of the agents:

$$K = \int_{\boldsymbol{M}} \int_{\boldsymbol{X}} a'(a, \boldsymbol{s}, d; \mu) \, d\nu \, dH, \tag{2.3.8}$$

$$L^f = \int_{\boldsymbol{M}} \int_{\boldsymbol{X}} e^f \left[1 - l^f(a, \boldsymbol{s}, d; \mu)\right] d\nu \, dH, \tag{2.3.9}$$

$$L^m = \int_{\boldsymbol{M}} \int_{\boldsymbol{X}} e^m \left[1 - l^m(a, \boldsymbol{s}, d; \mu)\right] d\nu \, dH. \tag{2.3.10}$$

4) The time-invariant stationary distribution ν is determined by the transition function P as

$$\nu(B; \mu) = \int_{\boldsymbol{X}} P(a, \boldsymbol{s}, d, B; \mu) \, d\nu \quad \text{for all} \quad B \in \mathcal{B}. \tag{2.3.11}$$

5) The government budget is balanced:

$$\int_{\boldsymbol{M}} \int_{\boldsymbol{X}} \big[\, \tau(y) - b \,\big] \, d\nu \, dH = G. \tag{2.3.12}$$

2.4 Parameterization and Calibration

2.4.1 Parameterization

Preferences. Instantaneous utility functions for females and males are parameterized as follows,

$$U^g(c, l) = \varphi_c^g \, \frac{c^{1-\sigma^g} - 1}{1 - \sigma^g} + \varphi_l^g \, \frac{l^{1-\gamma^g} - 1}{1 - \gamma^g} \qquad \text{for} \;\; g = f, m, \tag{2.4.1}$$

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where φ_c^g and φ_l^g are parameters (φ_c^f is normalized to one) and σ^g is the coefficient of relative risk aversion of an individual of gender g. It must be noted that in the model with collective households —and contrary to the model with bachelor households— the Frisch elasticity of labor supply of an individual of gender g depends not only on parameter γ^g, but is also a function of variables and parameters that affect the expected, intrahousehold earnings differential through the Pareto weight.[15] A household's risk aversion is determined by individual preferences for risk and by the household sharing rule μ. It is only when the two household members share the same preferences for risk, i.e., $\sigma^f = \sigma^m$, that the household's coefficient of relative risk aversion becomes independent of Pareto weights.[16]

Technology. As written above, production takes place according to the standard Cobb-Douglas technology, $F(K, L) = K^\alpha L^{1-\alpha}$, where labor is $L \equiv \lambda L^m + (1-\lambda)L^f$. Parameter α is the capital share of income and λ pins down relative gross wages, since $w^f/w^m = (1-\lambda)/\lambda$.

Labor efficiency. The stochastic process for labor productivity is modeled as a mapping from observed distributions of hourly wages net of fixed heterogeneity. Denote by ω_t^i the log hourly wage of individual i at time t and specify its evolution as

$$\omega_t^i \;=\; \beta_0^i \;+\; \beta_1\, x_t^i \;+\; \widetilde{z}_t^i \;+\; \iota_t^i\,, \qquad \text{with } \iota_t^i \overset{\text{i.i.d.}}{\sim} N(0, \sigma_\iota^2), \tag{2.4.2}$$

where β_0^i represents an unobserved fixed effect, x_t^i is a vector of observable characteristics such as age, gender and education, ι_t^i reflects measurement error and $\widetilde{z}_t^i$ is the time-varying component of an individual's log wage which corresponds to z_t^i in the model and evolves as posited in equation (2.3.2). Following Heathcote, Storesletten and Violante (2010), I assume that women and men face the same stochastic process for $\widetilde{z}$. This assumption mitigates the selection bias that may be caused by the unobservability of wages for non-working individuals: the reason is that the wage process specified above can be estimated using only data for men, for whom selection is a minor concern. In addition, I allow for a correlation structure of temporary shocks within married households. As for the permanent component of labor productivity, I impose that ξ can take on one of two values in $\Xi = \{0, \xi_c\}$, where ξ_c captures the skill wage premium of college-educated individuals. The fractions of females and males that are born with high ability will be denoted by q_c^f and q_c^m respectively.

Taxation. Following Guner, Kaygusuz and Ventura (2008), I construct income tax functions for single and married households based on estimates for effective taxes paid as a function of reported income. Using IRS data, Guner, Kaygusuz and Ventura (2008) estimate mean income and the average tax rate corresponding to each tabulated income bracket, and then fit

[15] See Ortigueira and Siassi (2010) for a derivation of Frisch elasticities in the collective household economy.

[16] See Ortigueira and Siassi (2010) for a derivation of the household's coefficient of risk aversion.

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a non-linear equation to the data for single and married households separately. The respective income tax functions are parameterized as follows:

$$\tau^{\mathcal{S}}(y) = [\,\kappa_0^{\mathcal{S}} + \kappa_1^{\mathcal{S}} \log(y)\,]\, y \tag{2.4.3}$$

$$\tau^{\mathcal{M}}(y) = [\,\kappa_0^{\mathcal{M}} + \kappa_1^{\mathcal{M}} \log(y)\,]\, y. \tag{2.4.4}$$

Pareto weights. I will make the following simplifying assumptions on the distribution of Pareto weights over the population of married households, G. In my benchmark economy, I impose that in all households where both members have the same permanent ability (i.e. either both are college-educated or both are not college-educated) relative Pareto weights are equal to 0.5. If abilities differ across household members, relative Pareto weights will in general be different from 0.5. Specifically, I assume that they are set such that the resulting allocation is consistent with empirical estimates for the sharing rule as presented in Browning et al. (1994).[17]

2.4.2 Calibration

The length of a period is set to one year. The model contains eight preference parameters, β, φ_c^m, φ_l^f, φ_l^m, σ^f, σ^m, γ^f and γ^m, and five demographic parameters, ϕ^D, ϕ^R, ψ, q_c^f, q_c^m. There are seven technology parameters, α, λ, δ, ρ, σ_ϵ, ϱ, ξ_{coll}, four matching probabilities, $q_{0,0}^f$, q_{0,ξ_c}^f, $q_{\xi_c,0}^f$, q_{ξ_c,ξ_c}^f, and two probabilities of having a descendant, $\pi^{\mathcal{S}}$ and $\pi^{\mathcal{M}}$. Finally, I have to specify thirteen parameters describing the policy of the government, $\kappa_0^{\mathcal{S}}$, $\kappa_1^{\mathcal{S}}$, $\kappa_0^{\mathcal{M}}$, $\kappa_1^{\mathcal{M}}$, b_0^f, $b_{\xi_c}^f$, b_0^m, $b_{\xi_c}^m$, $b_{0,0}$, $b_{\xi_c,0}$, b_{0,ξ_c}, b_{ξ_c,ξ_c}, G, and the derivative of the Pareto weight function with respect to x (to be detailed later), μ_1. Altogether, there are 40 parameters to be calibrated.

Demographics. My strategy is to set demographic parameters and matching probabilities such that the resulting composition of the population in the model mimics the actual population in the United States. Life-cycle parameters are determined as follows: individuals enter the working-age stage when they are 25, and they retire and die stochastically. I target the expected durations of their working lives and retirement to be 35 years and 20 years respectively. The shares of newborn females and males with college education are set to their empirical counterparts of 40.3 percent and 38.7 percent respectively. Furthermore, I target the empirical population shares of married couples with all four combinations of education mixes and the share of marriages leading to a divorce. From CPS data for the year 2009, I estimate that 50 percent of all households are married. Across all married households, there are 30.6 percent where both spouses are college-educated, 43.4 percent where neither spouse

[17] See Ortigueira and Siassi (2010) for a detailed description of this procedure.

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Table 3. Baseline Parameters

Description	Parameter	Value	Description	Parameter	Value
Discount factor	β	0.962	Gender premium	λ	0.562
Female risk aversion	σ^f	1.75	College premium	ξ_{coll}	0.560
Male risk aversion	σ^m	1.5	Wage persistence	ρ	0.914
Utility weight (f)	φ_c^f	1	Wage volatility	σ_ϵ	0.206
Utility weight (m)	φ_c^m	1.95	Cross-spouse correlation	ϱ	0.15
Utility weight (f)	φ_l^f	3.8	Fraction with college (f)	q_c^f	0.403
Utility weight (m)	φ_l^m	1.25	Fraction with college (m)	q_c^m	0.387
Regulates Frisch elasticity	γ^f	1.8	Matching probability	$q_{0,0}^f$	0.591
Regulates Frisch elasticity	γ^m	4.5	Matching probability	q_{0,ξ_c}^f	0.185
Probability of retiring	ϕ^R	1/35	Matching probability	$q_{\xi_c,0}^f$	0.274
Probability of dying	ϕ^D	1/20	Matching probability	q_{ξ_c,ξ_c}^f	0.613
Probability of divorce	ψ	0.0092	Probability descendant	$\pi^{\mathcal{S}}$	0.34
Capital share	α	0.36	Probability descendant	$\pi^{\mathcal{M}}$	0.89
Capital depreciation rate	δ	0.1	Derivative Pareto weight	μ_1	0.038

has college education, 11.9 percent where only the husband has been college-educated and 13.7 percent where only the wife has college education. As for the divorce rate, I target a 40-percent probability that married couples divorce before dying.[18] Given the demographic structure of the model, these targets uniquely pin down the four matching probabilities and the divorce probability, which implies that they can be calibrated externally (see Appendix II for a formal derivation). Finally, the probabilities of having descendants are set to match the population shares of single (69%) and married (89%) households with children.

Technology. Using estimates for the annual capital depreciation rate and the capital share of income, I set $\delta = 0.1$ and $\alpha = 0.36$, which are both standard values in the macro literature. The two parameters λ and ξ_{coll} characterize the gender wage gap and the college premium respectively. Using CPS data, I estimate a ratio between average female and male hourly wages of 0.78, and a ratio between average wages of college-educated individuals and non-college educated individuals of 1.75. The values of λ and ξ_{coll} are set to match these targets. The two parameter values characterizing the labor productivity process are set as in Flodén and Lindé (2001) who use the same specification and estimate $\rho = 0.914$ and $\sigma_\epsilon = 0.206$ from PSID data. Following Heathcote et al. (2010), I target a cross-spouse correlation for

[18] Divorce rates in the U.S. are typically estimated to be 40-50 percent with higher rates for teenage marriages, in particular in the first 5-10 years. Since agents enter my model at the age of 25, I choose a rate of 40 percent.

Table 4. Fiscal Policy Parameters

Description	Parameter	Value	Description	Parameter	Value
Tax function	κ_0^S	0.2028	Retirement benefits	b_0^m	0.1062
Tax function	κ_1^S	0.0497	Retirement benefits	$b_{\xi_c}^m$	0.1098
Tax function	$\kappa_0^{\mathcal{M}}$	0.1732	Retirement benefits	$b_{0,0}$	0.1548
Tax function	$\kappa_1^{\mathcal{M}}$	0.0733	Retirement benefits	$b_{\xi_c,0}$	0.1667
Public consumption	G	0.1125	Retirement benefits	b_{0,ξ_c}	0.1590
Retirement benefits	b_0^f	0.0900	Retirement benefits	b_{ξ_c,ξ_c}	0.1778
Retirement benefits	$b_{\xi_c}^f$	0.1062			

temporary shocks of 0.15.[19]

Preferences. I normalize φ_c^f to 1, which is equivalent to dividing both instantaneous utility functions by this parameter. Non-gender-based estimates of the average coefficient of relative risk aversion between 1 and 3 are common. When gender is taken into account, females are found to be more risk-averse than males. I set individual preferences for risk to $\sigma^f = 1.75$ and $\sigma^m = 1.5$. Estimates for males' Frisch elasticity of labor supply in the presence of potentially binding borrowing constraints range from 0.2 to 0.6 (see Domeij and Flodén 2006). Blundell and MaCurdy (1999) find that for females this elasticity is 3-4 times larger than for males. I target values of 0.45 and 1.25 for males and females, respectively. Utility weights are fixed to align with estimates for the amount of time people spend on market work. Specifically, I target median hours worked by single females (34.3 %), married females (30.4 %) and married males (38.0 %) as fractions of their discretionary time.[20] The subjective discount factor β is set to match a capital-output ratio of 3.

Government. Parameter values for single and married households' income tax functions are assigned on the basis of empirical estimates as reported in Guner, Kaygusuz and Ventura (2008). The coefficients they estimate are obtained by normalizing average income in each income bracket by mean household income. Hence, I have to adjust them appropriately by taking into account mean household income in my benchmark economy. Retirement benefits are calibrated on the basis of Social Security income data from the 2010 Current Population Survey. Specifically, I select all single and married households between 65 and 75 years and compute average benefits for each subgroup relative to b_0^f, the average Social Security income of a single female without college education. The value of b_0^f is then set to match a value

[19]See Hyslop (2001).

[20]These estimates are based on the 2010 wave of the Consumer Population Survey. I make the assumption that the disposable daily time endowment is 15 hours.

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of 20.9 % for the ratio between retirement benefits for that subgroup and mean household income in 2009. Finally, public consumption G is simply set to balance the budget of the government.

2.5 Results

2.5.1 The Benchmark model

As a first step, I will investigate whether my calibrated benchmark model can account for the cross-sectional distributions of earnings, income and wealth in the U.S. economy. To this end, I compute a selected variety of distributional statistics in my benchmark economy and compare them to their empirical counterparts. As a second step, I will ask whether my model does a significantly better job of accounting for the data than a more parsimonious model, which lacks some of the features I have introduced in the previous section.

Table 5 displays a summary of my results. For each of the three variables of main interest – labor earnings, income and net worth –, I contrast five distributional statistics of my benchmark economy with their corresponding empirical values. The first three statistics pertain to the shape of the respective distribution as measures of cross-sectional inequality, whereas the final two statistics directly address the discrepancy in per-capita values between married and single individuals. Table 5 suggests that the benchmark model does a good job of accounting for the salient features of the data. It succeeds to generate a degree of dispersion that is in accordance with the U.S. distributions of earnings, income and wealth, perhaps with the exception of the respective upper tails where it slightly understates the degree of concentration. Moreover, the model is capable of replicating the empirical fact that married individuals, on average, earn more income and hold more assets than singles.

A closer look at the first four rows reveals that the simulated economy does an excellent job of accounting for the distribution of labor earnings. At the upper tail, the 5 % households with the highest income from labor earnings earn 22 percent of total labor income, which is fairly close to the empirical value of 27.6 percent. The 40 % households with the lowest income from labor earnings earn only 0.3 percent of total labor income. The discrepancy to the empirical value of 4.7 percent can potentially be explained by the fact that in my economy households are by assumption not allowed to work anymore once they are retired (36.4 percent of the population). As for total income, the model does a very good job of accounting for the bottom tail. The fact that it slightly underpredicts the degree of dispersion at the upper tail is related to the shape of the wealth distribution. The reason is that there are not sufficiently

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Table 5. Summary of results

	Bottom 40%	Top 5%	Gini	Δ^{Mean}	Δ^{Median}
Labor earnings					
Data	4.7	27.6	0.59	+ 49.4	+ 83.3
Benchmark model	0.3	22.0	0.61	+ 33.8	+ 86.5
Reduced model	0.3	19.9	0.59	+ 23.9	+ 87.7
Total income					
Data	11.7	27.0	0.50	+ 26.8	+ 15.6
Benchmark model	13.6	18.6	0.44	+ 17.7	+ 59.3
Reduced model	15.5	16.2	0.40	+ 8.3	+ 46.3
Wealth					
Data	1.8	43.6	0.72	+ 33.5	+ 50.2
Benchmark model	3.9	25.0	0.61	+ 16.9	+ 66.7
Reduced model	5.2	21.2	0.56	− 20.5	− 2.6

many households accumulating extreme levels of wealth and, hence, having large incomes from capital gains. The lower tail of the wealth distribution is accounted for fairly well: in the benchmark economy the poorest 40 % households hold 3.9 percent of total wealth as opposed to the empirical value of 1.8 percent. Allowing for a positive borrowing limit could potentially explain the difference since there is a significant fraction of U.S. households holding negative net worth.

How well can the benchmark economy account for per-capita differences between married and single people? As can be seen in the last two columns in Table 5, the model successfully generates a positive divergence in means and medians for all three variables of interest. In the benchmark economy, married individuals earn on average 33.8 percent more labor income, their average total income is 17.7 percent higher, and they hold 16.6 percent more assets than singles. The corresponding per-capita gaps in median values are even more pronounced. For instance, the median married individual in the model is more than 66 percent richer than the median single individual. As for labor earnings the discrepancy in medians is particularly large and almost matches the value from the data, even though this statistic may be partially influenced by the fact that more than one third of all households have by assumption zero labor income. Altogether, the model matches the qualitative relations and mean and median gaps fairly well. Perhaps the only exception is the gap in median income, where the model predicts a significantly larger disparity than in means. A possible explanation is that the

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model abstracts from other sources of income – such as private and public transfers – that could have a mitigating effect on cross-sectional inequality.

How do these results compare to the implications of a standard incomplete-markets framework that lacks some features introduced in the benchmark model? Specifically, what is the role played by permanent skills, assortative matching, differences in effective taxation and directed bequests? To answer this question, I deactivate these features and solve a reduced version of the model (a precise description will be provided in the next section). As can be seen in Table 5, the reduced model performs considerably worse at accounting for the data in almost all dimensions. Importantly, per-capita differences in average earnings and income between married and single individuals are substantially lower than in the benchmark framework. Also, the reduced model fails entirely to generate a positive wealth gap – on the contrary, it counterfactually predicts that married individuals are on average more than 20 percent poorer than singles. In other words, the reduced model is not capable of explaining a household saving behavior that is consistent with the data, because it fails along one of the most important dimensions, namely the role of the marital status.

It is important to note that the reduced model closely resembles standard general equilibrium theories of inequality in a life-cycle setting (e.g. Castañeda et al. (2003) and De Nardi (2004)). While some of these models do a better job of matching the bottom and top tails of the income and wealth distribution, most of them abstract from the distinction between singles and couples and, hence, cannot be tested along this key dimension. The virtue of the reduced model is to show that augmenting a standard model in the most straightforward way, i.e. by introducing two household types, leads to counterfactual predictions. The benchmark model does a significantly better job of explaining the emergence of a positive per-capita wealth and income gap. Hence, it is natural to ask: which of its additional features are crucial and how do they contribute to the overall performance of the model?

2.5.2 Counterfactuals: A closer look at per-capita differences

In an attempt to shed more light on this question, I simulate a series of alternative models and compare their predictions for per-capita differences in earnings, income and wealth. The main objective is to evaluate the relative importance of three factors that distinguish the benchmark model from the reduced model: (i) the distinction between intentional and accidental bequests; (ii) the tax bonus for married households; and (iii) the role of education in conjunction with positive assortative mating. Starting from the benchmark model, I shut these three channels down one by one and recalibrate each model appropriately. The reduced model then refers to

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clusion of effective taxation (+6 percentage points) further contributes significantly to closing this gap. The intuition is that lower taxes imply a higher permanent income; consequently, married households accumulate more assets to target their wealth-to-permanent-income ratio. Finally, activating intentional bequests for households with descendants closes the wealth gap by another 13 percentage points. Stronger intergenerational ties among family households provide an additional incentive to save in order to transmit the household estate to the next generation.

Most of these observations for per-capita differences in means carry over to per-capita differences in medians. The benchmark model does a particularly good job in matching the empirical value for wealth. Note that a decomposition into the contributions of each of the three channels yields roughly equivalent numbers as in the previous analysis. Results for labor earnings are harder to interpret, because they are considerably influenced by the fact that a large share of the population has zero earnings. As for median income, all models somewhat fail to account for the empirical value. A potential explanation for this fact is that there may be other sources of income missing in the model economies.

To summarize, the findings in this section suggest that a standard incomplete-markets life-cycle model fails to account for the disparity in earnings and income. Even more importantly, it fails to account for the disparity in wealth, because it counterfactually predicts that single individuals are richer. The intuition is that married households share labor income risk efficiently, which leads them to save less for precautionary reasons.[23] The benchmark model does a significantly better job of matching the data. A comparison of various models shows that introducing permanent abilities is crucial to correctly account for per-capita differences in earnings and income. As for wealth, the tax bonus for married households and the distinction between intentional and accidental bequests both help to further close the gap to the data.

2.5.3 Intentional vs. accidental bequests

A novel feature of the theory put forward in this paper is the explicit distinction between voluntary and involuntary bequests. The idea is that households with descendants have a stronger propensity to leave their estates to future generations. In the model and my calibration, I have made the simplifying assumption that only parents of children enjoy bequeathing their assets upon death, whereas individuals with no children do not care about bequests. The purpose of this section is to address the validity of this assumption in light of some empirical

[23]The lower is the cross-spousal correlation of temporary shocks, the stronger is this effect. For instance, if the correlation was 0 instead of 0.15, the gap to the data would widen by another half a percentage point.

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Table 7. Net worth by number of children

	Fraction (in %)	Mean ($)	Median ($)
Married Households			
No children	10.7	446,700	155,000
At least 1 child	89.3	564,200	197,400
1 child	12.6	481,000	204,300
2 children	30.2	611,900	236,400
3 children	20.8	676,900	241,200
4+ children	25.6	555,600	171,700
Single Households			
No children	30.7	206,000	55,000
At least 1 child	69.3	206,800	64,400
1 child	14.6	197,400	51,100
2 children	24.7	234,300	88,400
3 children	13.5	202,500	76,100
4+ children	16.5	198,400	56,100

Source: 2007 wave of the Survey of Consumer Finances (SCF).

evidence. Also, I will discuss how the specification of the bequest function affects my results.

One of the model's implications is that households with descendants save more than households without descendants. Do we see something similar in the data? Table 7 presents descriptive statistics for net worth subdivided into the number of children for single and married households. As mentioned in the calibration part, the share of single households without children is higher than the share of married households without children. A closer look at the table reveals that mean and median wealth across married households are both increasing in the number of children. The exception is the last line: married households with four or more children are poorer than those with fewer children. Single households with two children appear to be significantly better off, on average, than those without children; apart from this relation, the picture is less clear. If one aggregates over households with and without children, there is a positive relationship between the presence of a descendant and net worth.

How do these figures compare to the predictions of the model? In the benchmark economy, married households with descendants hold on average 23.5 percent more assets than married households without descendants. The corresponding value from the data is 26.3 percent. A comparison of median wealth yields a gap of 22.6 percent in the model as opposed to an empirical value of 27.4 percent. Hence, the model does a fairly good job of accounting for the

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Table 8. Policy reform: Joint vs. separate tax filing

	K	L	Y	Gini	Δ^{Earn}	Δ^{Inc}	Δ^{Wealth}	Welfare
Joint filing	1.38	0.251	0.464	0.61	+ 33.8	+ 17.7	+ 16.9	–
Separate filing	1.36	0.247	0.457	0.62	+ 36.4	+ 18.9	+ 30.7	+ 8.5%

Note: Δ refers to the ratio of per-capita means as defined in (1). The Gini coefficient is computed for wealth.

pattern observed across married households. For single households the match is not as good: the median household with descendants holds 23.1 percent more wealth than the median household without descendants, and the corresponding difference in averages is 20.3 percent. This suggests that the bequest function specified for single households is not entirely capable of generating a saving pattern that is in accordance with the data. Alternatively, one could employ a more sophisticated calibration that discriminates probabilities of being assigned descendants across different education levels.

Overall, the findings in this section give rise to the notion that there may be an empirical justification for a distinction between accidental and intentional bequests – obviously, without proving causality. The bequest function chosen in the model has a straightforward and intuitive interpretation, because it relies on the assumption of full altruism across generations instead of an arbitrary functional form. Moreover, the pooling of assets across deceased single parents constitutes a novel way of modeling the transmission of wealth across generations. Quantitatively, this assumption ensures that the marginal value of bequeathing one unit of capital is of a similar magnitude as for married households.[24]

2.5.4 Policy experiment: Separate tax filing

An important implication of my findings so far is that married households benefit significantly from the bonus incorporated in the U.S. tax code. The reason is that married couples face considerably lower effective tax rates than two singles with the same characteristics, in particular, if individual incomes are very different. One of my counterfactual experiments has indicated that an upward-shift of effective tax rates for married households would drive down the per-capita wealth gap by about 6 percentage points (cf. Section 4.2). This section

[24] Consider an alternative specification under which individuals left their estate one-by-one to descendants. Then an additional unit of capital left by a single would fully capitalize into the endowment of the descendant. By contrast, an additional unit left by a married household would capitalize only as half a unit into the endowment of each of the two descendants. Under this specification the marginal bequest value would be much higher for singles.

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addresses the same issue in a more direct way by asking: what are the implications of a policy reform that abolishes the possibility to file taxes jointly? I evaluate this question in the context of a slightly modified version of my benchmark economy. The principle modification is that all agents, single or married, are now subject to the same effective tax schedule. Specifically, I assume that married individuals face the singles' tax function ($\tau^{\mathcal{S}}$), where income from capital gains is split equally between the two spouses. Any additional tax revenues resulting from this reform are then redistributed in the form of lump-sum transfers to all agents in the economy. For simplicity, I will focus on long-run effects and leave transitional dynamics aside.

Table 8 contrasts a selection of aggregate variables before and after the reform. The striking result of this exercise is that moving from joint to separate filing does not diminish economic inequality between single and married households; instead, per-capita disparities of earnings, income and wealth widen even more. This finding seems to stand in stark contrast to the counterfactual analysis carried out earlier. What is the intuition behind this result? Figure 1 shows that simply shifting up the tax schedule for married households yields a curve that still looks quite different from the tax function for singles. Importantly, the latter implies significantly higher tax rates for low income values. This means that married households cannot rely on favorable taxation when hit by adverse shocks; they are forced to save considerably more for precautionary reasons.

In the new stationary equilibrium, separate tax filing generates more total tax revenue. Lump-sum transfers induce agents to work less hours. Aggregate labor and aggregate capital are lower than before the reform, and total output decreases by 1.5 %. Moreover, the decrease in hours worked differs substantially by marital status (not shown): while single agents work 3.5 % less, married individuals work only 1.5 % less. This result is due to a combination of two forces. On the one hand, secondary earners face lower effective tax rates on labor income than under joint filing. On the other hand, there is an additional wealth effect, because higher taxation makes married households poorer. The model predicts that the reform leads to large welfare gains: expected welfare measured in consumption equivalents for a newborn increases by 8.5 %. The underlying force is a fiscal redistribution from married to single households. While inequality in terms of per-capita earnings and wealth appears to widen, consumption inequality actually decreases.

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2.6 Concluding Remarks

The model economy I present in this paper is largely successful at accounting for the empirical distributions of earnings, income and wealth across single and married households in the United States. One virtue of my benchmark model is that it is based on the standard incomplete-markets framework with idiosyncratic risk, which has proven to yield fairly accurate predictions pertaining to cross-sectional inequality. I demonstrate, however, that in its original version it fails in one of the key dimensions, namely the disparity in per-capita income and wealth between single and married households. In order to reconcile the model with the data, I propose several extensions and evaluate their relative contribution to the performance of the model. Moreover, I use my model to simulate the implications of abolishing joint tax filing for married couples.

To conclude, this paper should be considered as an intermediate step towards a refined understanding of the interaction between marriage and economic inequality. The model has various limitations that are worth exploring in future research. For instance, endogenizing marriage formation and destruction could help to account for the unexplained remainder of the wealth gap: if poor singles have a harder time to find a spouse than rich singles, and adverse labor market shocks lead to divorces, it is to be expected that the predicted wealth disparity increases even further. Another natural extension would be to introduce economies of scale in two-person households, for instance, by means of a public good. A careful quantitative analysis would, however, be complicated by the fact that there is yet no empirical consensus on the magnitude of such scale economies within the household. Finally, this paper has indicated important implications for policy design. It could be interesting to study policies that acknowledge the demand for redistribution by targeting single and married households in different ways.

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2.7 Appendix I: Data Sources and Variable Definitions

2.7.1 Survey of Consumer Finances (SCF)

The analysis is based upon the 2007 wave of the Survey of Consumer Finances (SCF). The SCF is conducted in three-year intervals and gathers detailed information on the financial situation of families in the United States. The survey is designed to obtain a sufficiently large and unbiased sample of wealthy households and provides appropriate weighting schemes to adjust for nonrespondents. The primary unit of observation is the household. A household comprises either an economically dominant single individual or a couple (married or living as partners) as well as all other individuals in the household who are financially interdependent with that individual or couple. I classify a household as married if the head of the household is legally married (and not separated), where I follow the SCF convention of defining the head as the male in core couple households. The following two restrictions are applied on the basic sample. First, I exclude all households where the head is less than 25 years old. Second, I exclude the richest 1 percent of married households and the richest 1 percent of single households. The remaining sample consists of 3,580 households; 2,366 of them are classified as married and 1,232 as single. I employ the following variable definitions:

Labor earnings. Wages + salaries plus two 66 % of business + self-employment income.

Total income. Sum of all income sources before taxes, i.e. wage income, self-employment income, net asset income, and private and public transfers.

Wealth. Net worth of the household, i.e. value of real and financial assets net of liabilities.

College education. Individual has obtained a college degree (variables x5904 and x6104).

2.7.2 Current Population Survey (CPS)

The analysis is based upon the March 2010 Supplement of the Current Population Survey (CPS). The CPS is the primary source of labor force statistics in the United States. A representative sample of currently around 60,000 households is interviewed about a set of demographic and labor force questions at a monthly frequency. The Annual Social and Economic Supplement (or 'March Supplement') augments the basic survey by a set of more detailed questions on income and is extended by an additional sample of around 34,5000 households.

I choose the family as the basic unit of observation and henceforth refer to it as a household interchangeably.[25] As a measure of preliminary data cleaning, I drop all households in which

[25] The primary unit of observation in the CPS is the "housing unit", which may include multiple families.

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there is at least one individual whose hourly wage is lower than half of the federal minimum wage in 2009. In addition, I exclude all households where the head is less than 25 years old. The remaining sample consists of 190,200 individuals organized in 77,368 households.

Next, I divide the main sample into two subsamples and call them married households and single households. A household is defined to be married if its head is currently married, and single otherwise. The definition of the household head can be described as follows. I first check whether there is an individual in the family that is of working age, i.e. between 25 and 60 years old. If so, the head is defined to be the oldest male person of working age or, alternatively, the oldest female person of working age in case there is no working-age male. If there are no individuals of working age in the household, I define the household head to be the oldest adult male (i.e. ≥ 18 years). If there are no adult males in the household, the head is defined to be the oldest adult female.

As a result, the subsample of married households consists of 126,165 individuals organized in 38,593 households. The subsample of single households consists of 64,035 individuals organized in 38,775 households. Labor earnings and total income are defined as for the SCF, where for both variables, respectively, I trim the data by excluding the bottom 0.5 percent of observations in order to deal with the problem of underreporting. Other variables are defined as follows:

Wage. To obtain an individual's hourly wage rate, I divide annual labor earnings by annual hours worked. Annual hours worked are computed as the product of the number of weeks worked and the number of hours worked per week (items '*wkswork*' and '*hrswk*').

Gender premium. I consider all working-age individuals who participate in the labor force, i.e. who work at least 260 annual hours (this corresponds to an average of 1 hour per working day). This sample consists of 74,792 individuals. The gender premium is computed as the ratio between the average wage rate earned by females and the average wage rate earned by males.

College: Individuals are defined to be college-educated if they have obtained some college degree (value of 41+ in item '*a-hga*'). To compute the college premium I consider the same sample that is used to compute the gender premium, and I calculate the ratio between the average wage rate earned by college-educated individuals and the average wage rate earned by non-college educated individuals. To partly control for the gender gap, I do this separately for both genders and then take the average.

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2.8 Appendix II

2.8.1 Population flows

Denote by $n^{\mathcal{M}}$, n^f and n^m the respective measures of married, single female and single male households in the population, where the total population size is normalized to $n^{\mathcal{M}}+n^f+n^m = 1$. Recall that married households die together and that the probability of dying is equal across retired single households of both genders. These assumptions imply that $n^f = n^m$. Denote by n^i_W and n^i_R the measures of working-age and retired households for each household type $i \in \{\mathcal{M}, f, m\}$, where by definition $n^i_W + n^i_R = n^i$. Population flows between different household types can then be described as follows:

Retired married households	–	Inflow:	$\phi^R\,(1-\psi)\,n^{\mathcal{M}}_W$
Retired married households	–	Outflow:	$\phi^D\,n^{\mathcal{M}}_R + (1-\phi^D)\,\psi\,n^{\mathcal{M}}_R$
Working-age married households	–	Inflow:	newborn married
Working-age married households	–	Outflow:	$\phi^R\,n^{\mathcal{M}}_W + (1-\phi^R)\,\psi\,n^{\mathcal{M}}_W$
Retired single households	–	Inflow:	$\phi^R\,n^g_W + \psi\,(1-\phi^D)n^{\mathcal{M}}_R + \psi\,\phi^R n^{\mathcal{M}}_W$
Retired single households	–	Outflow:	$\phi^D\,n^g_R$
Working-age single households	–	Inflow:	$(1-\phi^R)\,\psi\,n^{\mathcal{M}}_W +$ newborn singles
Working-age single households	–	Outflow:	$\phi^R\,n^g_W$

where $g = f, m$. For example, the measure of married households flowing out of retirement after each period is equal to the sum of two masses: the measure of households who die at the end of the period, $\phi^D\,n^{\mathcal{M}}_R$, and the measure of households who survive but divorce at the end of the period, $(1-\phi^D)\,\psi\,n^{\mathcal{M}}_R$. The measures of newborn single and married households will be described in more detail below.

It is important to note that in an equilibrium with stationary population measures inflows and outflows for each household type have to exactly offset each other. For instance, consider the measure of retired married households. Equalizing the first two expressions and using $n^{\mathcal{M}}_W = n^{\mathcal{M}} - n^{\mathcal{M}}_R$ yields

$$n^{\mathcal{M}}_R = \frac{\phi^R\,(1-\psi)}{\phi^D + (1-\phi^D)\,\psi + \phi^R\,(1-\psi)} \cdot n^{\mathcal{M}}.$$

Similarly, one can find an expression for the measure of retired female households:

$$n^f_R = \frac{\phi^R n^f + (1-\phi^D)\,\psi\,n^{\mathcal{M}}_R + \phi^R\,\psi\,n^{\mathcal{M}}_W}{\phi^D + \phi^R}.$$

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To derive the measures of newborn households, note that the mass of households dying at the end of each period is equal to $\left(\frac{1}{\phi^R}+\frac{1}{\phi^D}\right)^{-1} \equiv \overline{n}$. This implies that the total mass of newborn households is equal to $\overline{n}$. The share of newborn married households is determined by the weighted sum of individual matching probabilities during the household formation stage, $\sum_{i,j} q^g_{\xi^i,\xi^j} q^g_i \equiv \overline{q}$, where q^g_i is the probability that an individual of gender g is born with ability level i, and $\overline{q}$ represents the unconditional probability of being matched. It is then easy to show that the measure of newborn married households in each period is equal to $\overline{n}\,\overline{q}/(2-\overline{q})$. Equivalently, the measure of newborn single households is equal to $2\,\overline{n}(1-\overline{q})/(2-\overline{q})$, where half of them are single females and the other half single males.

2.8.2 Calibration of demographic parameters

The objective is to pin down values for $q^f_{0,0}$, q^f_{0,ξ_c}, $q^f_{\xi_c,0}$, $q^f_{\xi_c,\xi_c}$ and ψ given predetermined values for ϕ^R, ϕ^D, q^f_c and q^m_c and five empirical moments: the population shares of married couples with all four educational combinations and the share of marriages that lead to a divorce. First, note that the unconditional probability for a married working-age couple to be hit by a separation shock before dying is given by $(1-\psi)^{\frac{1}{\phi^R}+\frac{1}{\phi^D}}$. For any combination of ϕ^R and ϕ^D, the single-period divorce probability ψ then determines the targeted life-time divorce probability.

To pin down the matching probabilities, recall from the previous subsection that the measure of newborn married households flowing into working age is given by $\overline{n}\overline{q}/(2-\overline{q})$. In a stationary equilibrium this number has to equal the corresponding outflow:

$$\overline{n}\,\overline{q}/(2-\overline{q}) = \left[\phi^R + (1-\phi^R)\,\psi\right] n^{\mathcal{M}}_W = \left[\phi^R + (1-\phi^R)\,\psi\right]\left[n^{\mathcal{M}} - n^{\mathcal{M}}_R\right]$$

Plug in the expression for $n^{\mathcal{M}}_R$ as derived above:

$$\begin{aligned}
\overline{n}\,\overline{q}/(2-\overline{q}) &= \left[\phi^R + (1-\phi^R)\,\psi\right]\left[n^{\mathcal{M}} - \frac{\phi^R\,(1-\psi)}{\phi^D + (1-\phi^D)\,\psi + \phi^R\,(1-\psi)}\cdot n^{\mathcal{M}}\right] \\
\overline{n}\,\overline{q}/(2-\overline{q}) &= \left[\phi^R + (1-\phi^R)\,\psi\right]\left[\frac{\phi^D + (1-\phi^D)\,\psi}{\phi^D + (1-\phi^D)\,\psi + \phi^R\,(1-\psi)}\right] n^{\mathcal{M}}.
\end{aligned}$$

Given the overall share of married households $n^{\mathcal{M}}$, which is simply the sum of the empirical population shares of married couples with all four educational combinations, one can solve this expression for $\overline{q}$, the unconditional probability of being matched. Given $\overline{q}$, it is then straightforward to determine the four conditional matching probabilities $q^f_{0,0}$, q^f_{0,ξ_c}, $q^f_{\xi_c,0}$ and $q^f_{\xi_c}$ based on q^f_c and the relative frequencies of the four educational combinations across married households in the data.

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2.9 Appendix III: The Bequest Function

The bequest motive for single and married agents is closely linked to the expected value function for a newborn individual, which I denote as $\mathcal{W}$. Based on the likelihood to be selected into gender, education and household type respectively, and given that the initial time-varying labor efficiency component z is drawn from a Normal distribution through ϵ, one can construct $\mathcal{W}$ as a function of initial assets:

$$\mathcal{W}(a) = \frac{1}{2}\ E \sum_{g=f,m} \sum_{\xi^i \in \Xi} q^g_{\xi^i} \left(\sum_{\xi^j \in \Xi} q^g_{\xi^i,\xi^j} \int \widetilde{V}^g(a,s)\, d\epsilon + \Big(1 - \sum_{\xi^j \in \Xi} q^g_{\xi^i,\xi^j}\Big) \int V^g(a,s)\, d\epsilon \right),$$

where $V^g(a,s)$ is the value function of a single agents of gender g as defined in (2.3.6), and $\widetilde{V}^g(a,s)$ is the value function of a married agent of gender g. Note that $\widetilde{V}^g(a,s)$ is implicitly defined by the collective household's Pareto problem and can be computed accordingly.

The bequest function for married households with descendants, $\mathcal{Z}(a',1)$, can now be derived as follows. Since there is no intergenerational transmission of abilities, the bequest motive does not depend on individual labor efficiencies and is, thus, identical for both agents in the household. As a result, the bequest function does not depend on relative Pareto weights and simply reads

$$\mathcal{Z}\left(a',1\right) = \mathcal{W}(a'/2).$$

The bequest function for single agents is slightly more involved, because they pool their estates with a randomly selected single agent of opposite gender. Since they do not know the quantity of assets contributed by the other parent before dying, they form rational expectations based on the actual distribution of assets in the population. Denote by ν^g the measure of single households of gender $g \in \{f,m\}$. Then the bequest function for a single female household is given by

$$\mathcal{Z}^f\left(a',1\right) = \int_S \int_A \phi(s)\, \mathcal{W}\Big(\left(a' + a^P(a,s^m,1)\right)/2\Big)\, d\nu^m,$$

where I have renamed the policy function of single male agents to $a^P(a,s^m,1)$ in order to avoid any confusion with a'. Similarly, the bequest function for a single male household is given by

$$\mathcal{Z}^m\left(a',1\right) = \int_S \int_A \phi(s)\, \mathcal{W}\Big(\left(a' + a^P(a,s^f,1)\right)/2\Big)\, d\nu^f.$$

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Chapter 3

On the Implications of Intrahousehold Risk Sharing for Unemployment Insurance

Keywords: Unemployment Insurance; Intrahousehold Risk Sharing; Gender-Based Taxation.

JEL Classification Numbers: D13; E21; E62; I38; J65.

3.1 Introduction

Unemployment benefit programs are often motivated on the grounds of providing insurance against idiosyncratic income fluctuations. When lump-sum taxation is not available and private capital markets are incomplete, the welfare-maximizing government faces a trade-off between public risk sharing through redistribution on the one hand, and efficiency losses due to distortionary taxation on the other hand. This trade-off has been the subject of many recent studies.[1] An aspect that has mostly been overlooked in the literature, however, is how the optimal provision of social insurance is shaped by informal sources of private insurance, the most important one being the family. If individuals are able to share part of their income risk with family members, for instance in households with multiple breadwinners, the demand for public insurance may be reduced. At the same time, the design of unemployment benefit schedules can have an influence on intrahousehold risk-sharing agreements themselves, for

[1] See, e.g., Attanasio and Ríos-Rull (2000), Thomas and Worrall (2007), Heathcote (2005), Kocherlakota (2006), Golosov and Tsyvinski (2007), and Krüger and Perri (2010).

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instance, if they affect the balance of power within families. In that case, taxation and the provision of benefits may even lead to unforeseen effects, depending on how policy distorts the allocation that family members bargain upon.

In this paper, these arguments are formalized in an incomplete-markets model with uninsurable, idiosyncratic employment shocks. The focus of the paper lies on the interaction between public unemployment insurance and private intrahousehold insurance. I choose to contrast two polar economies: on the one hand, an economy in which individuals can rely on efficient risk sharing within the household, and, on the other hand, an economy in which they cannot. The first economy is populated by a large number of two-person households, each pooling risk and making collective decisions on individual consumptions, labor supplies and joint savings in a risk-free asset, subject to a borrowing constraint. The two persons forming a household, a female and a male, are assumed to have different individual preferences for risk and different elasticities of labor supply. In the second economy, by contrast, individuals form single-person households and, thus, lack access to family insurance. The latter framework is a version of the standard Aiyagari-Bewley-Huggett model which has been studied extensively in this literature.

Equipped with these two model economies, I wish to investigate how the provision of public unemployment insurance intertwines with private insurance mechanisms. To this end, I calibrate the model economies to U.S. data and simulate a series of policy reforms that alter the current public insurance scheme. For any policy reform, I compute the stationary equilibrium that would arise after implementing it in either economy. Upon comparing implications for allocations and welfare, I can characterize the role of intrahousehold risk sharing for unemployment insurance. A further contribution of my analysis is to study policies targeting females and male in distinct ways. For instance, I can assess whether there are efficiency arguments for unconventional schemes such as gender-based taxation[2] or wage subsidies.

My main findings can be summarized as follows. First, reducing the generosity of unemployment benefits leads to welfare gains in both model economies. This suggests that private forms of insurance seem to work sufficiently well to justify less distortionary taxation – even if insurance from the family is not available. Second, the two models have very different predictions about who realizes those welfare gains. If intrafamily risk sharing is available, the collective bargaining agreement induces females to work more hours since they supply labor more elastically. As a result, they suffer welfare losses and all efficiency gains are realized by males. By contrast, the model without intrafamily insurance predicts that females are better-

[2]This idea has been put forward recently by Alesina et al. (2011).

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off. Since males hold more capital, they suffer welfare losses – the reason is that lower public insurance implies more precautionary saving which, in turn, depresses returns on capital.

In a further experiment, I evaluate the implications of a revenue-neutral reform that prescribes different replacement rates for females and males. My findings indicate that higher replacement rates for males – at the expense of lower replacement rates for females – can have welfare-improving effects in an economy where intrahousehold risk sharing is available. The intuition is that household income fluctuates to a larger extent if males are hit by an unemployment shock than if females are unemployed. As a result, smoothing household income by means of more generous male replacement rates benefits females and males at the same time. The model also predicts aggregate welfare gains even if intrahousehold risk sharing is not available.

Are there efficiency grounds for taxing female and male labor income at different rates? I find that this is indeed the case. Shifting the tax burden from the high-elasticity good (female labor) to the low-elasticity good (male labor) reduces distortions and raises aggregate welfare. This result holds independently of whether individuals can share risk within the household or not. Interestingly, subsidizing female labor supply may actually lead to welfare losses for females themselves if they are bound to family insurance: when female market hours become relatively more productive, the collective household allocates more labor supply to women, a pattern that is additionally amplified by a large labor elasticity. For instance, if the government lowers the tax rate on female labor by 3 percentage points, females would work on average 3 % more hours, whereas males would decrease their market work by only 0.9 %.

The study most closely related to this one is Di Tella and MacCulloch (2002). These authors investigate potential crowding-out effects of unemployment benefits on intrafamily insurance. Their model features families consisting of a number of self-interested individuals who share labor income risk through informal contracts with limited commitment. Defecting from a contract leads to exclusion from future risk-sharing arrangements within the family. Di Tella and MacCulloch (2002) show that in their model more generous public transfers can lead to a more than one-by-one reduction in intrafamily insurance. The reason is that exclusion from intrafamily risk sharing becomes relatively more attractive, which reduces the set of incentive-compatible contracts. The main difference to their paper is that I do not investigate the issue of limited commitment and moral hazard within the household. Instead, I focus on the distinct implications public transfers can have depending on whether intrafamily contracts are actually available or not.

The rest of the paper is structured as follows. The two model environments are presented

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in Section 2, and Section 3 summarizes the calibration strategy. In Section 4, I describe the results of my numerical experiments. Section 5 offers some concluding remarks.

3.2 The Model

Consumers. Consider an economy that is populated by a continuum of infinitely-lived consumers/workers. Half of them will be referred to as females, and the other half as males. All individuals enjoy the consumption of an aggregate good and of leisure time. Agents supply time to work in the production sector and face idiosyncratic labor market risk in the form of employment shocks. Employment shocks, s, take on values in $S \equiv \{0, 1\}$ and follow a Markov chain with transition matrix Π^i, where superscript i denotes the gender: females (f) and males (m). Thus, $\pi^i_{s'|s}$ is the probability for an agent of gender i to receive employment shock s' tomorrow conditional on employment shock s today, for $i = f, m$. These probabilities satisfy $\sum_{s'} \pi^i_{s'|s} = 1$, $\pi^i_{s'|s} > 0$, and $\pi^i_{1|1} \geq \pi^i_{1|0}$ for $i = f, m$. The long-run probabilities of the two employment shocks in S are denoted by q^i_0 and q^i_1. There are no others shocks in the economy.

Markets are incomplete. The only asset in the economy is physical capital, which pays out the risk-free interest rate r. Moreover, I assume that individuals in this economy are not allowed to borrow. This imposes a zero lower bound on their asset holdings. Lifetime preferences for an agent of gender i over stochastic consumption and leisure streams are given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U^i(c_t, l_t), \quad \text{for} \quad i = f, m, \tag{3.2.1}$$

where c_t denotes consumption, l_t is leisure and β denotes the discount factor. I will assume that U^i is strictly increasing and strictly concave in each of its arguments, twice continuously differentiable and satisfies the Inada conditions.

Firms. Production of the aggregate good is conducted by a continuum of competitive firms. The representative firm operates a technology that can be represented by the Cobb-Douglas production function $F(K, L) = K^{\alpha} L^{1-\alpha}$, where K is the aggregate stock of capital, L is aggregate labor and $0 < \alpha < 1$ is the capital's share of income. Female and male labor are assumed to be perfect substitutes, $L \equiv \lambda L^m + (1 - \lambda) L^f$, where λ is a parameter that pins down relative productivities and can thus be used to model the gender gap in wages. The depreciation rate of capital is denoted by $0 < \delta < 1$. The firm's maximization problem is static: given a rental price of capital r and gross wages for females and males $\bar{w}^f$ and $\bar{w}^m$,

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respectively, first-order conditions are:

$$F_K(K,L) = r+\delta \tag{3.2.2}$$

$$\lambda F_L(K,L) = \bar{w}^m \tag{3.2.3}$$

$$(1-\lambda)F_L(K,L) = \bar{w}^f. \tag{3.2.4}$$

Government. There is a government that provides public insurance against unemployment shocks. The government pays out benefits b^i to unemployed workers of gender $i = f, m$. Only workers who receive an unemployment shock are entitled to benefit payments. The government finances its expenditures by levying linear taxes on labor income: given tax rates τ^i, I will denote after-tax wage rates by $w^i = (1-\tau^i)\bar{w}^i$. The government is required to balance its budget on a period-by-period basis.

3.2.1 The Bachelor Model

I now consider two different risk-sharing arrangements and study their implications for public unemployment insurance. Each arrangement defines in turn a different type of household. I start out by presenting the problem of the bachelor household. The defining feature of this type of household is that a single breadwinner chooses sequences of consumption, leisure and asset holdings in order to maximize his/her own lifetime utility. A household formed by a single agent of gender i solves

$$\begin{aligned} v^i(s,a) &= \max_{c,l,a'} \left\{ U^i(c,l) + \beta \sum_{s'} \pi^i_{s'|s} v^i(s',a') \right\} \qquad (3.2.5) \\ \text{s.t.} \quad & c + a' = w^i(1-l)s + (1-s)\, b^i + (1+r)a \\ & c \geq 0, \quad 0 \leq l \leq 1, \quad \text{and} \quad a' \in [0,\bar{a}], \end{aligned}$$

where $\pi^i_{s'|s}$ are the elements of Π^i.[3]. By construction, the bachelor household does not engage in informal insurance arrangements with other workers. The only sources of insurance available to this type of household are the public unemployment insurance system, own savings and own labor supply.

3.2.2 The Collective Model

The second risk-sharing arrangement I consider is the two-person collective household, which is formed by an egotistical female and an egotistical male. I assume that the two members

[3]For the sake of notational brevity, I omit the dependence on prices r and w^i in an individual's value function.

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of the household share labor market risk in such a way that intrahousehold allocations are efficient. Following the literature of collective households (see Chiappori and Donni 2010 for a recent survey), the utility of each individual in the household carries a weight, reflecting the relative power of that individual in the household. Individual weights are assumed to depend on variables such as premarital wealth, the population sex ratio, relative earnings and government policy. Under full commitment, that is, when household members can commit to future intrahousehold allocations, individual weights are set when the household is formed and remain unchanged thereafter. Thus, transitory shocks, which are small relative to lifetime income, have no effect on individual weights. Only variables known or predicted at the time of household formation can affect those weights. In my model there are four sources of earning differences between females and males that affect relative Pareto weights: 1) They have different gross wages; 2) They may pay different tax rates; 3) They may receive different levels of unemployment benefits; and, 4) Finally, females and males may be subject to different employment and unemployment spells. I write the Pareto weight on female's utility as $\mu(x,) \in (0,1)$, where function μ is assumed to be differentiable with respect to its first argument. Variable x is a measure of the relative earning ability of the two spouses, which I write as,

$$x \equiv \frac{q_1^f(1-\tau^f)\bar{w}^f + q_0^f b^f}{q_1^m(1-\tau^m)\bar{w}^m + q_0^m b^m}, \tag{3.2.6}$$

where q_i^j for $j = f, m$ and $i = 0, 1$ is, as written above, the long-run probability of employment state i for an agent of gender j. It must be noted that in this model the Pareto weight function, $\mu(x)$, is not obtained as the outcome of an explicit bargaining process between females and males. Instead, I will use estimates of the sharing rule provided by Browning, Bourguignon, Chiappori and Lechene (1994) to parameterize and solve the model.

Household-level state variables for the two-person, collective household are the vector of employment shocks $\boldsymbol{s} = (s^f, s^m)$, which I assume to be uncorrelated within the household, and the level of asset holdings, a.[4] The state space of a household is $X = S \times S \times [0, \bar{a}]$. I denote by $\mathcal{B}$ the Borel sigma algebra of X. The transition matrix for $\boldsymbol{s}$ is denoted by Π and obtained from the individual transition matrices as $\Pi = \Pi^m \otimes \Pi^f$. The maximization problem of a

[4]See Ortigueira and Siassi (2010) for an empirical justification of the assumption of uncorrelated shocks.

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collective household with Pareto weight $\mu(x)$ reads

$$
\begin{aligned}
V(\boldsymbol{s},a;x) \quad &= \max_{c^f,c^m,l^f,l^m,a'} \left\{ \mu(x)U^f(c^f,l^f) \; + [1-\mu(x)]U^m(c^m,l^m) + \beta \sum_{\boldsymbol{s'}} \pi_{\boldsymbol{s'}|\boldsymbol{s}} V(\boldsymbol{s'},a';x) \right\} \\
\text{s.t.} \quad & \\
& c^f + c^m + a' = \sum_{i=f,m} w^i(1-l^i)s^i + \sum_{i=f,m} (1-s^i)\, b^i + (1+r)a \qquad (3.2.7) \\
& c^f,\ c^m \geq 0, \quad 0 \leq l^f,\ l^m \leq 1, \quad \text{and} \quad a' \in [0,\bar{a}],
\end{aligned}
$$

where $\pi_{\boldsymbol{s'}|\boldsymbol{s}}$ are the elements of Π. Note that while I allow for different preferences over consumption and leisure for females and males, I assume that both spouses share a common discount factor β. Contrary to unitary models of the household, the utility function of the collective household depends, *via* the Pareto weight, on wages and policy variables, which leads to household demands that fail to meet the Slutsky conditions. This failure is the defining feature of the collective model. Also, while in unitary models household decisions do not depend on who receives the income within the household, in the collective model decisions depend on total income as well as on who receives the income (whether it is the female or the male).

3.2.3 Stationary Equilibrium with Incomplete Markets

I now define a stationary equilibrium with incomplete markets in the collective household economy. Let $\psi(B;\mu)$ be a probability measure describing the mass of households with fixed Pareto weight μ at each point in the state space X, where $\psi(B;\mu)$ is defined on the Borel sigma algebra $\mathcal{B}$. Denote by $P(\boldsymbol{s},a,B;\mu)$ the probability that a household with Pareto weight μ at state $(\boldsymbol{s},a)$ will transit to a state that lies in $B \in \mathcal{B}$ in the next period. The transition function P can be constructed as

$$P(\boldsymbol{s},a,B;\mu) = \sum_{\boldsymbol{s'} \in B_{\boldsymbol{s}}} \Pi_{\boldsymbol{s'}|\boldsymbol{s}}\, \mathcal{I}_{a'(\boldsymbol{s},a;\mu) \in B_a},$$

where $\mathcal{I}$ is an indicator function taking on a value of 1 if its argument is true and 0 otherwise, and $B_{\boldsymbol{s}}$ and B_a are the projections of B on $S \times S$ and $[\underline{a},\overline{a}]$ respectively. Note that these transition functions will in general differ across households with different Pareto weights μ. I am now ready to define the equilibrium concept for the model.

Definition: A stationary recursive competitive equilibrium with incomplete markets in the economy with collective households is a list of functions $\{V, c^f, c^m, l^f, l^m, a', K, L^f, L^m\}$, a measure of households ψ and a set of prices $\{r, \bar{w}^f, \bar{w}^m\}$, taxes $\{\tau^f, \tau^m\}$ and benefits $\{b^f, b^m\}$ such that:

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1) For given prices, taxes and benefits, V is the solution to (3.2.7), and $c^f(\boldsymbol{s}, a; \mu)$, $c^m(\boldsymbol{s}, a; \mu)$, $l^f(\boldsymbol{s}, a; mu)$, $l^m(\boldsymbol{s}, a; \mu)$ and $a'(\boldsymbol{s}, a; \mu)$ are the associated optimal policy functions.

2) For given prices, K, L^f and L^m satisfy the firm's first-order conditions (3.2.2) – (3.2.4).

3) Aggregate factor inputs are generated by the policy functions of the agents:

$$K = \int_M \int_X a'(\boldsymbol{s}, a; \mu) d\psi dG, \tag{3.2.8}$$

$$L^f = \int_M \int_X s^f [1 - l^f(\boldsymbol{s}, a; \mu)] d\psi dG, \tag{3.2.9}$$

$$L^m = \int_M \int_X s^m [1 - l^m(\boldsymbol{s}, a; \mu)] d\psi dG. \tag{3.2.10}$$

4) The time-invariant stationary distribution ψ is determined by the transition function P as

$$\psi(B; \mu) = \int_X P(\boldsymbol{s}, a, B; \mu) d\psi \quad \text{for all} \quad B \in \mathcal{B}. \tag{3.2.11}$$

5) The government budget is balanced: $q_0^f b^f + q_0^m b^m = \tau^f \bar{w}^f L^f + \tau^m \bar{w}^m L^m$.

3.3 Parameterization and Calibration

3.3.1 Parameterization

Preferences. Instantaneous utility functions for females and males are parameterized as follows,

$$U^i(c, l) = \varphi_c^i \frac{c^{1-\sigma^i} - 1}{1 - \sigma^i} + \varphi_l^i \frac{l^{1-\gamma^i} - 1}{1 - \gamma^i} \quad \text{for} \quad i = f, m, \tag{3.3.1}$$

where φ_c^i and φ_l^i are parameters (φ_c^f is normalized to one) and σ^i is the coefficient of relative risk aversion of an individual of gender i. It must be noted that in the model with collective households —and contrary to the model with bachelor households— the Frisch elasticity of labor supply of an individual of gender i depends not only on parameter γ^i, but is also a function of variables and parameters that affect the expected, intrahousehold earnings differential through the Pareto weight.[5]

Technology. As written above, the production takes place according to the standard Cobb-Douglas technology, $F(K, L) = K^\alpha L^{1-\alpha}$, where labor is $L \equiv \lambda L^m + (1 - \lambda) L^f$. Parameter α is the capital share of income and λ pins down relative gross wages, since $\overline{w}^f / \overline{w}^m = (1 - \lambda)/\lambda$.

[5]See Ortigueira and Siassi (2010) for a derivation of Frisch elasticities in the collective household economy.

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Pareto weights. Since all households are ex-ante identical, they have the same relative Pareto weight. For my benchmark economy, I will make the simplifying assumption that relative Pareto weights are equal to 0.5. I also need the derivative of the Pareto weight function with respect to x, $\mu'(x)$, in order to pin down the Frisch elasticities of labor supply. I will set the value of this derivative using empirical estimates of the sharing rule. I detail this empirical evidence and my procedure below.

3.3.2 Calibration

The model contains eight preference parameters: β, φ_c^m, φ_l^f, φ_l^m, σ^f, σ^m, γ^f and γ^m. There are three technology parameters: α, λ and δ. The two transition matrices Π^f and Π^m contain four parameters. The public insurance program is described by tax rates and the level of unemployment benefits: τ^f, τ^m, b^f and b^m (one of the tax rates is determined from the balanced-budget constraint). Finally, I have to pin down the derivative of the Pareto weight function with respect to x, μ_1.

The length of a period in the model is set to one quarter. I normalize φ_c^f to 1, which is equivalent to dividing both instantaneous utility functions by this parameter. In order to calibrate the remaining parameters I choose a set of statistics from aggregate and household survey data for the U.S. economy, such that the incomplete markets equilibrium of the collective household economy matches these targets. Using estimates for the quarterly capital depreciation rate and the capital share of income, I set $\delta = 0.025$ and $\alpha = 0.36$, which are both standard values in the macro literature. In my benchmark economy, I impose equal labor income tax rates for females and males, $\tau^f = \tau^m$. Consequently, the value for λ can be pinned down using *a priori* information on the gender wage gap. I set this parameter equal to 0.575, which implies a ratio of female to male wages of 0.74. This corresponds to the gender wage gap in 2004 as reported by Heathcote, Storesletten and Violante (2010) for the U.S. economy.

Transition probabilities for idiosyncratic employment shocks are assumed to be identical for females and males. I use the following transition probabilities which match an average employment rate of 93% after normalizing with the participation rate,

$$\Pi^i = \begin{pmatrix} 0.09 & 0.91 \\ 0.06 & 0.94 \end{pmatrix} \quad \text{for } i = f, m. \tag{3.3.2}$$

The remaining twelve parameters are set such that the model matches the following targets:

1. Married females' average hours of work if working represent 28% of their discretionary

time. Married males' average hours of work if working represent 40% of their discretionary time.[6]

2. Estimates for males' Frisch elasticity of labor supply in the presence of potentially binding borrowing constraints range from 0.2 to 0.6 (see Domeij and Flodén 2006). Blundell and MaCurdy (1999) find that for females this elasticity is 3-4 times larger than for males. I will target values of 0.37 and 1.2 for males and females, respectively.

3. Non-gender-based estimates of the average coefficient of relative risk aversion have yielded values ranging from 1 to 10. When gender is taken into account, females are found to be more risk-averse than males.[7] I set individual preferences for risk at $\sigma^f = 2$ and $\sigma^m = 1.5$, which yield an average coefficient of relative risk aversion for the collective household of 1.68.

4. The capital-to-output ratio is around 10.

5. The ratio of annual hours worked by single working women to annual hours worked by single working men is $1861/2095 = 89$ percent.[8] I will match this value using the equilibrium of the bachelor economy.

6. The average net unemployment benefit replacement rate in the United States is roughly 30 percent (see OECD 2010). I will set b^f and b^m to match this target as fractions of the average wage income both for females and males. Labor income tax rates are set to balance the budget constraint of the government.

7. The derivative of the Pareto weight function with respect to the expected income differential, μ_1, is set to match the sharing rule estimates presented in Browning, Bourguignon, Chiappori and Lechene (1994).[9]

Table 1 presents parameter values for my benchmark economy.

[6] Mazzocco, Ruiz and Yamaguchi (2008) use PSID data from 1968 to 1996 to compute mean annual hours worked if working for married females and males; he finds values of 1660 and 2312 respectively. I assume that the disposable daily time endowment is 16 hours.

[7] For a recent study of risk aversion and gender see Maestripieri, Sapienza and Zingales (2009), who find a negative relation between testosterone levels and risk aversion.

[8] See Mazzocco, Ruiz and Yamaguchi (2008).

[9] See Ortigueira and Siassi (2010) for further explanation.

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Table 1. Baseline Parameters

Description	Parameter	Value	Description	Parameter	Value
Female risk aversion	σ^f	2	Utility weight	φ_c^f	1
Male risk aversion	σ^m	1.5	Utility weight	φ_c^m	2.15
Regulates Frisch elasticity	γ^f	2	Utility weight	φ_l^f	2.662
Regulates Frisch elasticity	γ^m	3.75	Utility weight	φ_l^m	0.911
Pareto weight	μ	0.5	Discount factor	β	0.989
Derivative Pareto weight	μ_1	0.038	Unemployment benefits	b^f	0.083
Capital income share	α	0.36	Unemployment benefits	b^m	0.161
Depreciation rate of capital	δ	0.025	Relative wages	λ	0.575

3.4 Results

3.4.1 The Benchmark Economies

Before turning to the results of my fiscal policy experiments, I will briefly describe the steady-state allocations of the two benchmark economies. Table 2 summarizes aggregate variables for the collective household economy and the bachelor household economy. Note that the two economies differ only in the insurance opportunities available to individuals, and, therefore, differences in aggregates variables reflect equilibrium effects of intrahousehold risk sharing. Aggregate capital is higher in the bachelor economy, as the lack of insurance from the family in this economy leads individuals to rely more on savings. Aggregate work effort by females and males ranks differently in the two economies. While male labor is higher in the collective economy, females work more in the bachelor economy. In the bachelor economy, females are relatively poorer and, since they lack the consumption insurance provided by the family, must supply more hours of work. Males finance part of female consumption in the collective economy (even with equal Pareto weights) and must therefore work longer hours. Total labor is higher in the bachelor household economy. The capital-labor ratio is lower in the economy with intrahousehold risk sharing, yielding a higher interest rate as compared to the economy with bachelor households. Finally, production is higher in the economy with bachelor households, which results from larger aggregate capital and labor.

Next, I will lay out the design of my fiscal policy reforms. Starting from the two benchmark economies, I simulate a series of experiments that alter the structure of the unemployment insurance system in distinct ways. Specifically, I simulate the following policy reforms:

1. **"Change replacement rate" (E1):** Change the replacement rate of unemployment

Table 2. Steady-state equilibrium: Aggregate variables

	Y	K	L	K/L	K^f	K^m	L^f	L^m	$100 \cdot r$
Collective economy	1.272	12.682	0.349	36.335	–	–	0.280	0.400	1.1115
Bachelor economy	1.308	13.041	0.359	36.345	4.724	8.326	0.336	0.375	1.1109

benefits and let the labor income tax rate adjust to balance the government budget. In this scenario replacement rates and tax rates remain equalized across females and males.

2. **"Change combination of replacement rates" (E2):** Keeping the tax rate on labor income constant, change the combination of replacement rates for females and males. In this scenario replacement rates differ, but the tax rate remains the same for both genders.

3. **"Change combination of tax rates" (E3):** Keeping the replacement rates constant, change the combination of labor income tax rates for females and males. In this scenario replacement rates are equalized, but tax rates are gender specific.

For each experiment and each economy, I compute the new steady-state equilibrium that would arise after the policy reform has been put in place. When examining the impact on aggregate variables and welfare in the two economies, I will ignore transitional dynamics and focus on long-run effects. Moreover, I will simulate each reform for a wide range of different values in order to potentially detect non-linear effects; for instance, experiments E1 and E2 are conducted for replacement rates between zero and 40 percent. Similarly, I will allow for negative tax rates (i.e. subsidies) in experiment E3. The underlying objective is to employ all available policy instruments in the widest possible meaningful way. Aggregate welfare is computed using a utilitarian criterion and measured in terms of consumption equivalent units. In addition to calculating expected welfare gains for a generic agent, I will also present welfare effects for females and males separately.

3.4.2 Experiment 1: Change replacement rate

The first experiment aims at quantifying the trade-off between less taxation – and thus a lower extent to which intratemporal decisions are distorted – versus more public insurance against uninsurable adverse shocks. Figure 1 plots aggregate welfare as a function of the replacement rate of unemployment benefits for both benchmark economies. As can be seen, both curves

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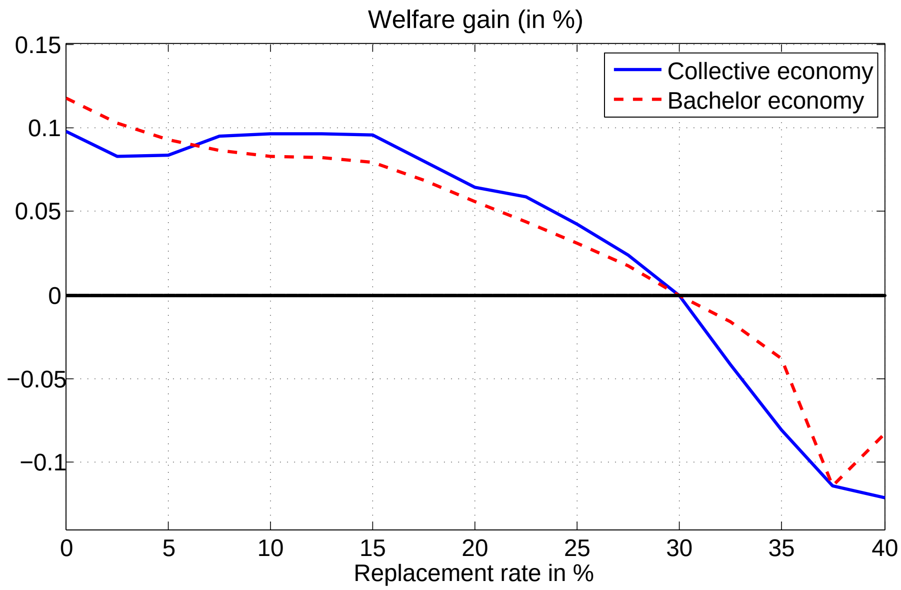

Figure 3.1: Welfare effect of changing the replacement rate (Experiment 1)

exhibit fairly similar shapes: welfare increases as the replacement rate is lowered to about 15 percent and then levels off. By contrast, raising replacement rates beyond 30 percent – the benchmark value – unambiguously depresses welfare in both economies. This suggests that there is relatively little scope for public insurance, because private means of insurance – precautionary saving, adjustments to labor supply and, potentially, insurance from the family – work fairly well against unemployment risk. The magnitude of welfare effects is modest: for instance, lowering the replacement rate to 15 percent would have a positive welfare effect of 0.09 percent (measured in consumption equivalent units) in the collective economy, and of 0.07 percent in the bachelor economy.

While aggregate welfare effects look very similar in both model economies, intrahousehold risk sharing has a very distinct impact on gender-specific welfare effects (Figure 2, upper panels). Lowering replacement rates makes males considerably better off than in the benchmark economy, but only if intrahousehold risk sharing is available. By contrast, they suffer welfare losses when living in a single household. For females the opposite is true: they benefit from lower replacement rates, but only when living alone. To gain some intuition for this result, it is useful to look at the general equilibrium forces on factor prices (Figure 2, lower panels). If individuals must rely less on public insurance, precautionary saving as one means of private insurance increases. This depresses the interest rate through a higher capital supply and

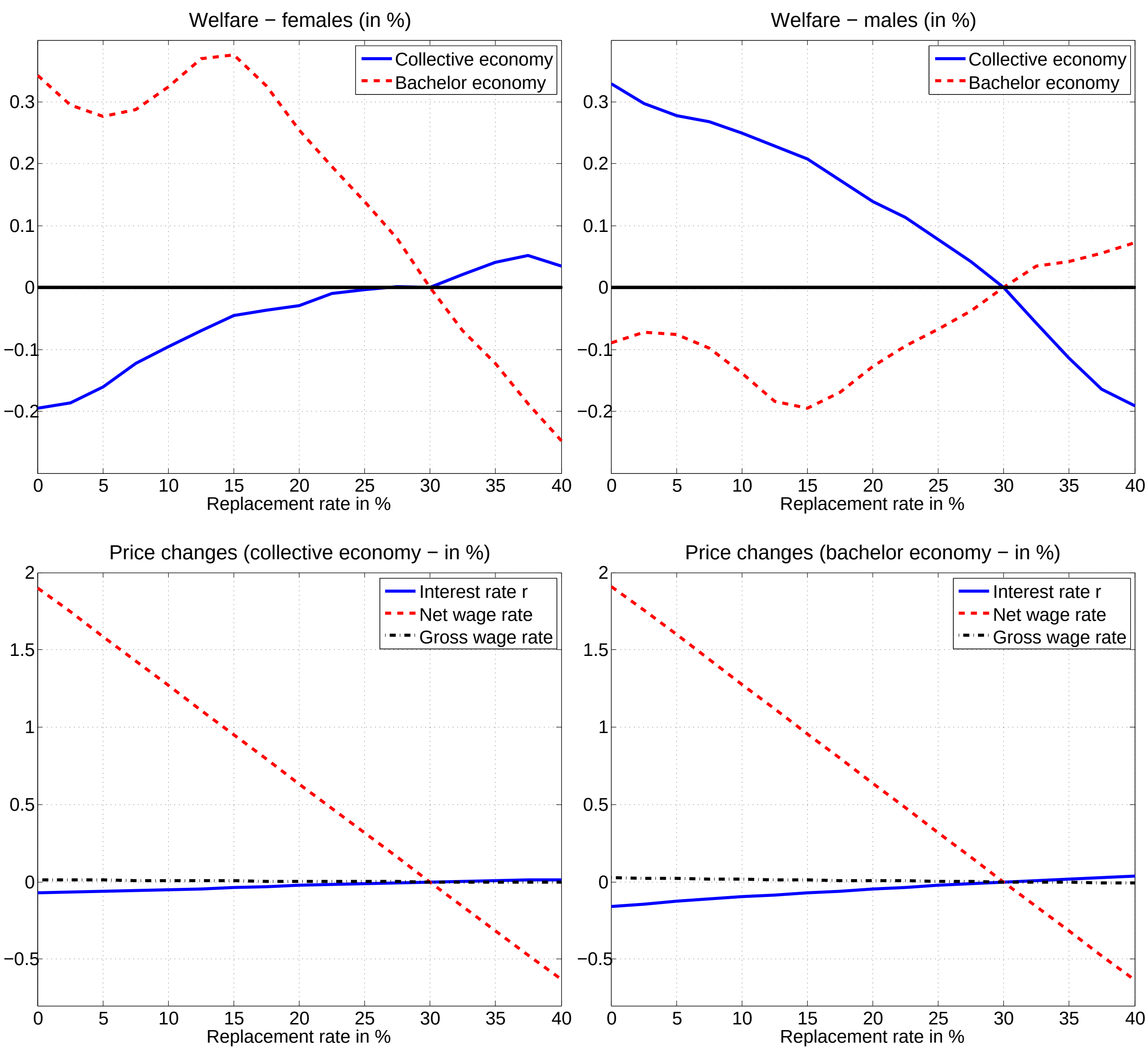

Figure 3.2: Welfare effect by gender and price effects of changing the replacement rate (E1)

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raises wage rates. Moreover, since the need to finance benefits through labor income taxation diminishes when replacement rates are lowered, net wage rates rise even further.[10]

In the bachelor economy, females are favored through higher returns to labor and they are less affected by lower returns to capital, because they hold on average fewer assets than males. Males have a larger permanent income and, hence, target a larger stock of buffer savings, which becomes relatively more costly as the wedge between the subjective time preferences rate and the returns to capital opens up. In the economy with intrahousehold risk sharing, from an ex-ante point of view, factor price movements affect all households in the same way. As replacement rates are lowered and the labor wedge is reduced, the collective household allocates more time to market work and to consumption. Females are relatively worse off, because they supply labor more elastically and benefit relatively little from more consumption; as a result, efficiency gains are realized by males.

To summarize, the first experiment suggests that private insurance against unemployment suffices to justify less public insurance – even without intrahousehold risk sharing. Gender-specific welfare effects, however, critically depend on the type of living arrangement.

3.4.3 Experiment 2: Change combination of replacement rates

Females and males exhibit different attitudes towards risk and supply labor more or less elastically. Is there scope for policies addressing gender heterogeneity in preferences explicitly, for instance, by providing different levels of public insurance? The second policy experiment answers this question in the context of a fiscal reform that leaves the revenue side untouched – i.e. tax rates are kept at their benchmark value – yet discriminates the generosity of unemployment benefits across genders. Under this reform, lower replacement rates for females imply higher replacement rates for males, and vice versa.

Figure 3 shows expected welfare gains as a function of the replacement rate for females in the collective and in the bachelor economy. Interestingly, in both economies welfare rises as the generosity of males' benefits increases at the expense of benefits for females. The magnitude of welfare gains is substantially lower if intrahousehold risk sharing is available. For instance, reducing the replacement rate of females' benefits to 15% would imply a replacement rate for males of 37.8% and an aggregate welfare gain of 0.01% in the collective economy. In the bachelor economy a similar policy reform would imply a replacement rate for males of 39.5% and an aggregate welfare gain of 0.5%. Gender-specific welfare effects, once again, look very

[10] Recall that female and male labor are perfect substitutes. This implies that wage changes for females and males are proportional.

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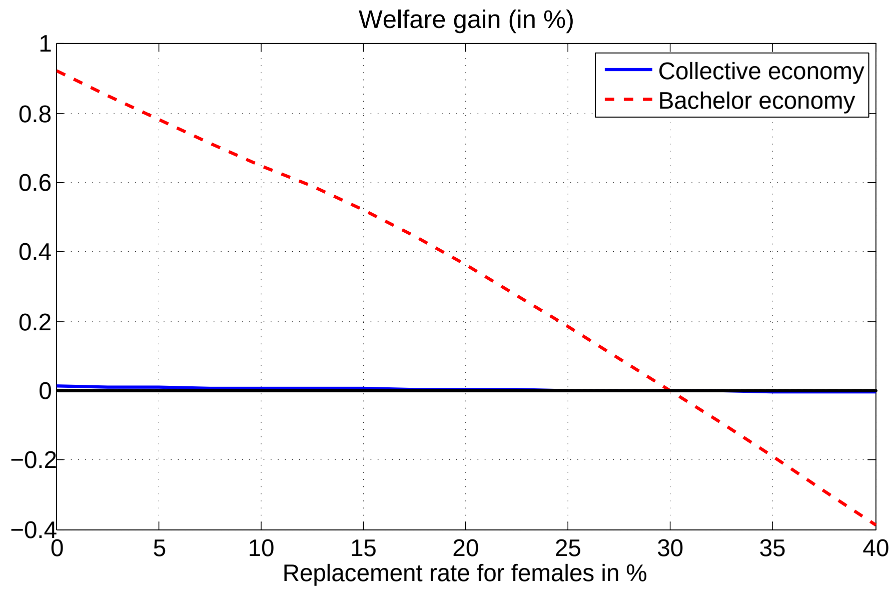

Figure 3.3: Welfare effect of changing the replacement rate for females (Experiment 2)

different in the two models (Figure 4). In an economy where unemployment risk is shared within the household, both spouses benefit from a policy reform that shifts the generosity of public insurance to males (Figure 4, upper-left panel). The intuition behind this finding is that allocations made within the collective household do not crucially depend on the source of unemployment benefits – the impact on relative Pareto weights is too small quantitatively to play a significant role. Therefore, for a given level of public insurance, the collective household prefers to smooth male income during unemployment spells at the expense of smoothing female income, because the income loss is substantially larger if the husband is unemployed. As a result, precautionary savings diminish and the interest rate on capital has to rise to clear the market (Figure 4, lower-left panel).

The corresponding figures for the bachelor economy look counterintuitive at first glance: expected welfare for females rises in response to lowering their replacement rate, whereas males suffer welfare losses (Figure 4, upper-right panel). To explain this result, one has to bear in mind that gender-specific welfare measures are based on the distribution of females and males that arise in a stationary equilibrium. If males expect more insurance from unemployment benefits, they save less for precautionary reasons, while the opposite is true for females. As a consequence, in the long run females accumulate more assets and become richer than males.[11]

[11]This result is substantially favored by the fact that capital supply in this model is very elastic. If there

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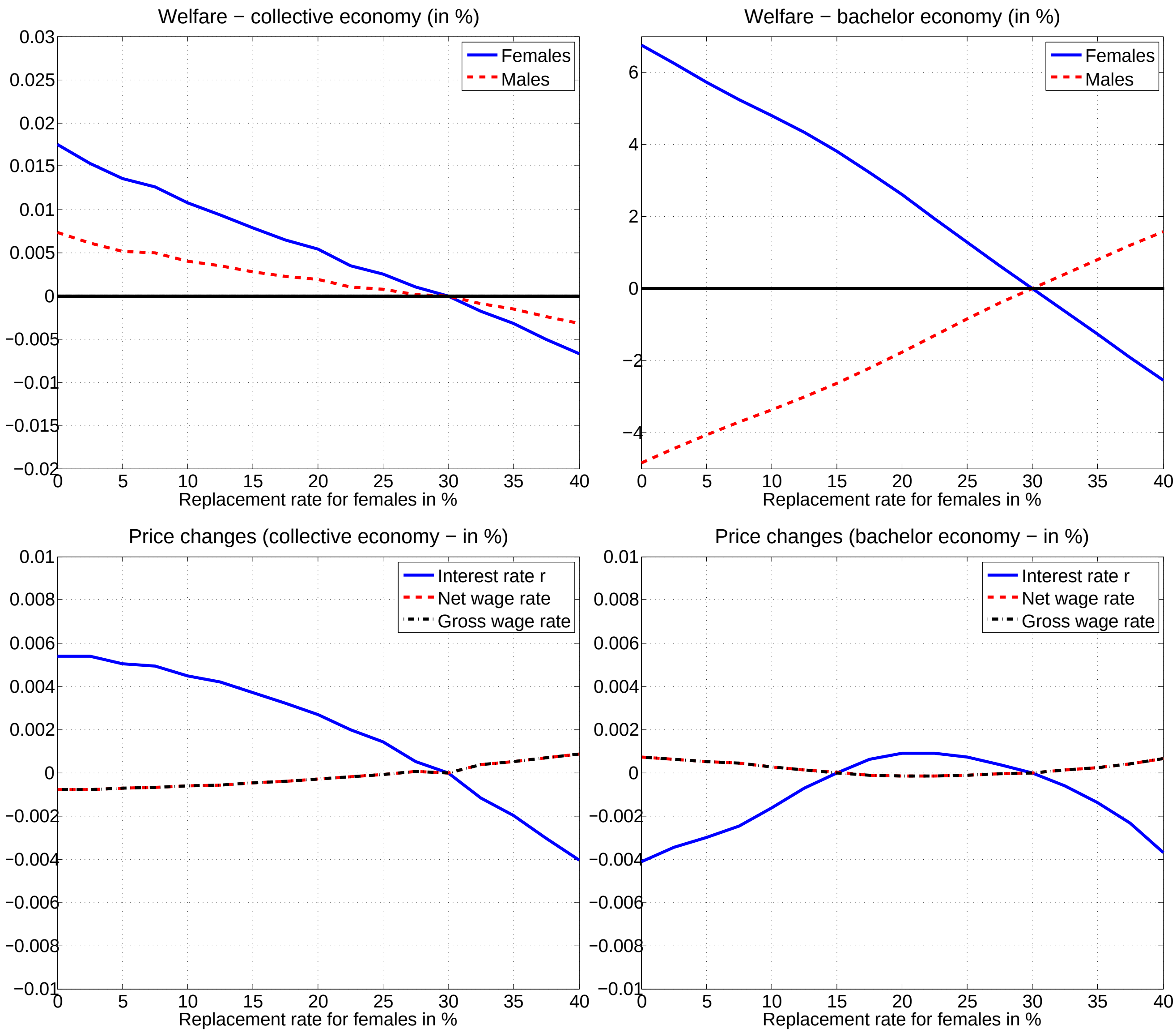

Figure 3.4: Welfare effect by gender and price effects of changing the female repl. rate (E2)

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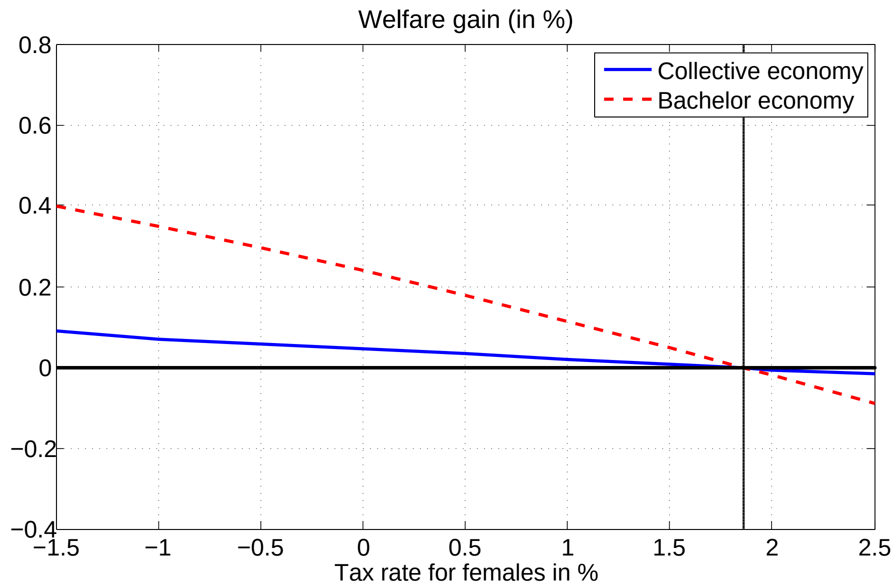

Figure 3.5: Welfare effect of changing the tax rate for females (Experiment 3)

Therefore, computing aggregate welfare on the basis of stationary distributions somewhat conceals the fact that, for a given level of assets, males are better off with a higher replacement rate. It is important to note that is not a price effect: interest rates and wage rate remain almost constant, because changes in capital supply by agents of both genders essentially offset each other (Figure 4, lower-right panel).

3.4.4 Experiment 3: Change combination of tax rates

The third policy experiment picks up a notion that has recently attracted some attention among labor economists – the idea of gender-based taxation. It is inspired by the Ramsey rule, which states that, in order to minimize distortions, goods with a lower demand elasticity should be taxed at higher rates. In the current context, lower labor income tax rates for women at the expense of higher tax rates for men could reduce overall distortions, given that women supply labor more elastically. For this experiment, I take the expenditure side of my benchmark economies as given – i.e. I leave benefits untouched – and only change the composition of the revenue side.

Results are shown in Figure 5. Starting from a common tax rate of 1.86 percent (vertical

were other sources of risk, variations to unemployment insurance would have a much weaker impact on saving patterns.

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solid line), lowering tax rates on females' labor income indeed leads to welfare gains in both economies. Note that these welfare gains are relatively large compared to the previous experiments. For instance, a negative tax rate (i.e. a subsidy) of 1.5 percent on female labor income would raise aggregate welfare by 0.4 percent in the bachelor economy and 0.1 percent in the collective economy. Such a reform would have to be financed by in increase in the male tax rate to 4.08 percent (bachelor) and 3.59 percent (collective) respectively.

Gender-specific welfare effects and net wage changes are depicted in Figure 6.[12] A reduction of tax rates on female labor income raises their net wage and lowers male net wages through higher taxes on male labor. If no intrahousehold risk sharing is available, welfare effects are as expected: females gain and males lose. Interestingly, this result is overturned if employment risk is shared efficiently within households. When female market hours become relatively more productive, the collective household allocates more labor supply to women, a pattern that is additionally amplified by a larger female labor elasticity. In the previous example of a 1.5-percent subsidy, females would work on average 3 percent more hours, whereas males would decrease their market work by only 0.9 percent (not shown).

Overall, these findings suggest that shifting the tax burden from the high-elasticity good (female labor) to the low-elasticity good (male labor) may indeed reduce distortions and raise aggregate welfare. Yet it is important to note that such a policy of reducing the gender wage gap would not necessarily favor females.

3.4.5 Composite policy reform

In the previous parts, I have examined the implications of single modifications to the unemployment insurance system in both economies. As a final exercise, this section proposes an exemplary policy reform that is composed of various changes to the benchmark. The objective is to conduct a quantitative assessment of this reform in terms of important aggregate variables and welfare, and to highlight the driving forces depending on whether intrahousehold risk sharing is available or not. Specifically, the unemployment insurance system after the reform shall be characterized as follows: (a) reduce the replacement rate to 15% and freeze total expenditures that would be necessary to finance benefits at this level; (b) decrease the replacement rate of female benefits further to 12.5% and raise the replacement rate of male benefits accordingly to keep total expenditures constant; (c) set the tax rate on female labor income to zero and raise the tax rate on male labor income accordingly to finance benefits.

[12] Net wage changes and price changes are only shown for the collective economy. The corresponding figures for the bachelor economy are very similar.

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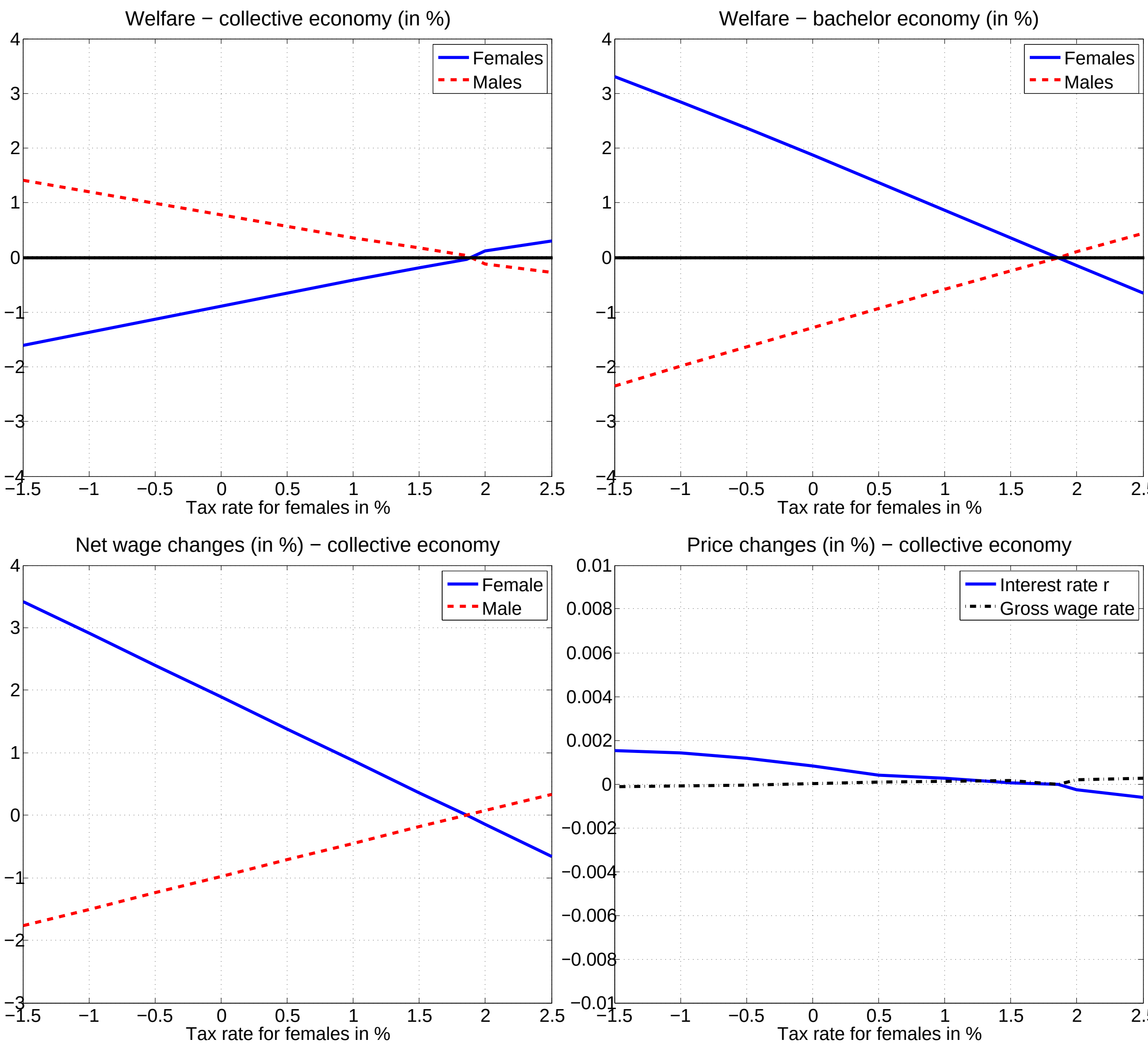

Figure 3.6: Welfare effect by gender and price effects of changing the tax rate for females (E3)

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Table 3. Composite policy reform: Change in aggregate variables (in %)

	Y	K	L	L^f	L^m	W^f	W^m	W
Collective economy	+ 0.40	+ 0.37	+ 0.42	+ 1.40	− 0.08	− 0.56	+ 0.54	+ 0.056
Bachelor economy	+ 0.12	+ 0.13	+ 0.11	− 0.48	+ 0.50	+ 1.57	− 1.01	+ 0.236

Table 3 summarizes the long-run implications of this policy reform mix. Aggregate capital and aggregate labor increase independently of whether intrahousehold risk sharing is available or not. Total output increases by 0.4 percent in the collective economy and by 0.12 percent in the bachelor economy. When differentiated by gender, the reform generates distinct adjustments in both economies. While females choose to work less in an economy with bachelor households, they work longer hours when sharing risks with a spouse: the collective model predicts an increase of female labor supply by almost 1.5%. Hours worked by males remain almost unaffected in the economy with intrahousehold risk sharing, whereas in the bachelor model males choose to work longer hours. The reform mix brings about welfare gains in both economies: measured in consumption equivalents, expected welfare goes up by 0.06% and 0.24% respectively. Gender-specific welfare effects depend very much on risk-sharing opportunities, though: while females draw relatively large benefits from the modified unemployment insurance system when living as bachelors, they suffer significant losses when living in a collective household; the opposite is true for males.

3.5 Concluding Remarks

The main contribution of this study is to show that the trade-off between distortionary fiscal policy and public risk sharing may be critically affected by informal risk sharing agreements such as the family. Reforms to the design of the unemployment insurance system typically have distinct implications for individual and aggregate allocations, depending on whether intrahousehold risk sharing is available or not. It is also revealed that policies targeting individuals of one gender can lead to unexpected outcomes, if they do not acknowledge the bargaining process between spouses. Finally, there is some evidence that gender-based taxation and replacement rates can give rise to welfare and output gains.

The framework presented in this paper involves a number of restrictions. For example, since only unemployed workers are entitled to benefits, there is no endogenous participation decision. Introducing voluntary unemployment would create an additional margin that could play a role when comparing the collective household to the bachelor household. Since females are typically secondary earners in multi-person households, higher taxes and overgenerous benefits could both distort incentives. A related extension worth pursuing could be to investigate policy reforms that condition benefit payments on the employment status of the spouse, if present. Family insurance is shown to go a long way in smoothing income and consumption, as long as either of the two breadwinners is employed. Providing additional public insurance for the worst-case scenario, i.e. when both spouses are unemployed, at the expense of less insurance for intermediate cases, i.e. when only one spouse is unemployed, could improve the benefit of public risk sharing without touching the taxation side.

A different way to proceed would be to add labor market frictions to the model. There is a large literature studying the interaction between unemployment insurance and labor market outcomes if workers have to search for jobs and are matched stochastically. However, very little work has been done on how the presence of multiple persons in the household impacts on these theories.[13]

[13] Guler, Guvenen and Violante (2009) take a first step in that direction.

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